Fortification
AND
Military Diſcipline
In Two Parts.

The Firſt ſhews the Principles and Practice of all manner of Fortifications, *Regular* or *Irregular*, as now uſed by the *Dutch*, *Engliſh*, *Italian*, *German*, and *French* Ingeniers.

The Dimenſions and Meaſures of the *Rampires*, *Parapets*, *Moats*, and all other Parts.

The Delineations of *Ravelins*, *Halfmoons*, *Tenails*, *Hornworks*, *Crownworks*, and *Cittadels*.

As alſo the making of *Batteries*, *Approaches*, *Trenches*, *Mines*, *Aſſaults*, &c.

The Second Part treats of the Rules for the Exerciſe of *Horſe* and *Foot*, with all ſorts of *Inſtructions* and other *Obſervations* belonging to the *Whole Art of War*, as now practiſed.

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Improved and Deſigned by Capt. *J. S.*

Publiſhed and Sold by *Robert Morden* at the *Atlas* near the *Royal Exchange* in *Cornhil*, *London*. 1688.

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DEFENSIVE
OFFENSIVE
Plate III
ARTIFICIAL
NATURAL
MODERNE
ANCIENT
IRREGULER
REGULER

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MVSEVM
BRITAN
NICVM

THE

Publiſher

TO THE

READER.

POſſible it is that ſome may ſlight and contemn this Treatiſe of Fortification and Military Diſcipline, becauſe it comes abroad without being Fortified and Defended by ſome Noble and Martial Patron. Let ſuch know, that it was ſo intended, but the Mine by Contra-Approaches was ſtrangely Countermined, ſo that the Unfortunate Author is forced to lie Intrenched in his Donjon, to the end he may not be condemned without hearing, or wounded without Defence. He very well knows, that Vulgar Opinion is very malicious and ſevere, like Soldiers in a Storm who kill and deſtroy without Witneſs or Judge. But if in any thing this may be uſeful to his Country, he will not much lament his Misfortune that compelled him to retire into his Bulwarks. If not, a Dedication can yield him no other ſatisfaction at this time, than a fair Sun-ſhine Day to a Seaman after Shipwrack;

Shipwrack; *and therefore the Undertaker is forced to Publiſh it*, *thus weak and open*, *to the Aſſaults and Batteries of every confident and raſh Attacker*, *and ſhall only draw about it this ſmall but real* Traverſe *or* Parapet. *That it is the moſt* plain, eaſie, *and* compleat Treatiſe *ever extant in the* Engliſh Tongue. *'Tis true*, *there have been* ſome Books *of this* Art *in* Engliſh *before*, *but if I ſhould declare* at large *how* defective, *and how* little ſatisfactory *in ſeveral* Uſes *and* Directions, *as well as in the* Draughts, *and* lively Delineations *of every* Particular *here inſerted*, *I ſhould be too large for an* Epiſtle, *and ſome would be ready to tell me*,

Laudat venales, *qui vult extrudere*, *merces.*

If any Artiſt *or* Ingenier *ſhall carp at ſome* Rules *and* Directions *as too* plain *or* prolix, *give me leave to ſay*, *That it was* Calculated *for the* Meaneſt Underſtandings, *and not deſigned to* teach *the* more Learned *(though*, *'tis poſſible*, *they may find* ſomewhat more *than they knew before) but to learn others not* experienced *in the* Practice, *who by their* Induſtry, *and theſe* Directions, *may eaſily* attain *to be more ſerviceable to their* KING, *and thereby acquire* Reputation *and* Honour.

As for the Original Authors, viz. Tacquet, *Count* Pagan, Bocklern, Mallet, Blundel, *who*, *as they are well known*, *ſo they are highly eſteemed and approved in all Martial Countries*, *and therefore cannot be diſreſpected here.*

I need not therefore plead *any thing more either for the* Book, *or for the* Art; Empires, Kingdoms, Nations *and* People *cannot ſubſiſt*, *without* Practice *and*

and Experience *in it. And forasmuch as none are born* Soldiers, *and* Experience *comes not without* Industry, *I hope our* Englisſh Nation *will not* ſlight *and* neglect *it, and ſo fruſtrate the* Deſigns *and* Expectations *of a* MARTIAL SOVEREIGN.

Pardon me *therefore, if I affirm, That the more we* practiſe *this* Art, *the more* Courage *it will* inſpire *into us, and the better* enable *us to ſerve our* KING *and* Country; *Which is the hearty Deſire of*

Your moſt humble, & moſt obedient, Servant,

ERRATA.

PAge 11. line 21. for *b.* read *d.* p. 14. l. 22. r. *Prob.* 8. p. 18. l. 24. for *Fig. XIII.* r. *XIV.* p. 23. l. 2. for *Diviſion* r. *Definition*, p. 24. for *Definition* r. *Diviſion*, p. 25. l. 20. for *Definition* r. *Explanation*, p. 26. l. 5. for *C D.* r. *C G.* p. 37. l. 13. for *ſ. q.* r. 6. *d.* p. 38. l. 26. for 9. r. q, p. 43. l. 13. for *Plate* 7. r. 9. p. 53. for *B C.* r. *B D*, p. 44. l. 12. for 2. 8. r. 6. 7. p. 46 and 47. for 8. *d.* r. 7. *c.* p. 56. l. 29. for $7\frac{1}{2}$ r. $1\frac{1}{2}$ p. 58. for *B C.* r. *X.* 4.

A TREATISE OF

Fortification,

AND

MILITARY DISCIPLINE, &c.

CHAP. I.

Of Geometrical Definitions.

WELL knowing that many Gentlemen and Soldiers, to whom I desire this Work may be as delightful as useful, are not very well skilled in *Geometry*, or of much knowledge in other parts of the *Mathematicks*; Therefore, to make the knowledge of *Fortification* the more plain and intelligible to them, I thought it convenient to lay down the first Rudiments and Practices introductive thereunto.

Geometry is the Art of measuring Bodies, in order to which end it considers three principal things, *viz.* Points, Lines, Superficies or Surface, which, in their proper Notion, do signifie the Outside, the Edge, and the Corners of the Body, and so are real parts of it; But, in a Geometrical Sense, they do not properly belong to a Body,

but are applied to it by Imagination: For if a Body be put into Water, though the Water touches it everywhere, yet we may fancy a Diviſion between it and the Water, which imaginary Diviſion is called a Surface. And thus every imaginary Diviſion of a Body begets a Surface between the Parts ſo divided, of a Surface begets a Line, of a Line begets a Point.

A Point is that which hath no parts either of Length or Breadth, and is the Bounds of a Line ordinarily expreſſed by a ſmall Prick.

A Line hath Length, but no Breadth, and is the Bounds of a Surface, and is either right or crooked.

A Superfiices or Surface hath length and breadth, but no Depth, and is the Bounds and Limits of a Body.

Of Figures.

A *Figure* is a plain Surface incloſed in one or more Lines, and is of two kinds, a Circle, and a Right lined Figure.

Of a Circle. Plate 1. Fig. 1.

A *Circle* is a round Figure, whoſe Superficies or *Area* is bounded with one Line called the Circumference or Periphery, and is always divided into 360 degrees or parts, the Point in the midſt whereof is called the *Centre c.* a Line paſſing through the Centre dividing the Circle into two equal parts, is called the *Diameter a. b.* half of that Line is called a *Semidiameter* or *Radius c. b.*

or

Plate 1

Fig. II.

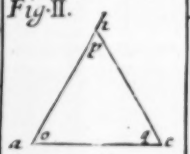
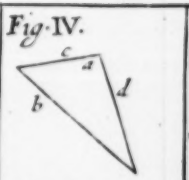


Fig. III.

Fig. IV.



Compasses

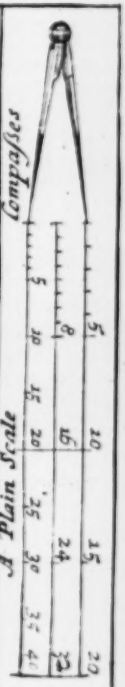


Fig. V.

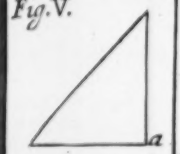


Fig. VI.

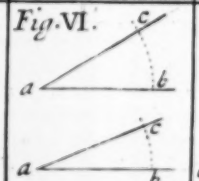


Fig. VII.

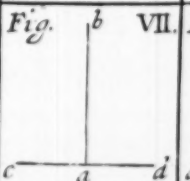


Fig. VIII.

Fig. IX.

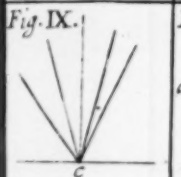


Fig. X.

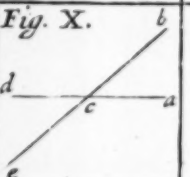


Fig. XI.

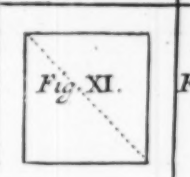
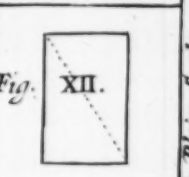
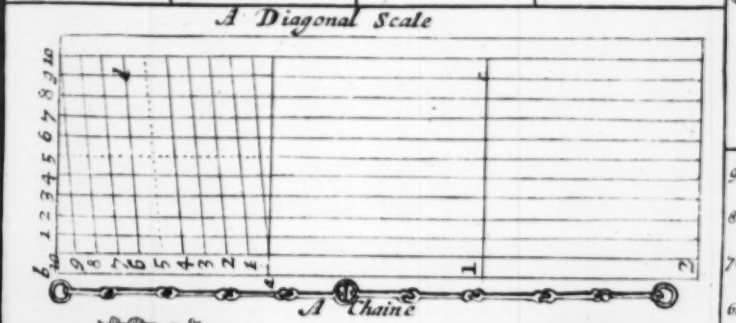


Fig. XII.

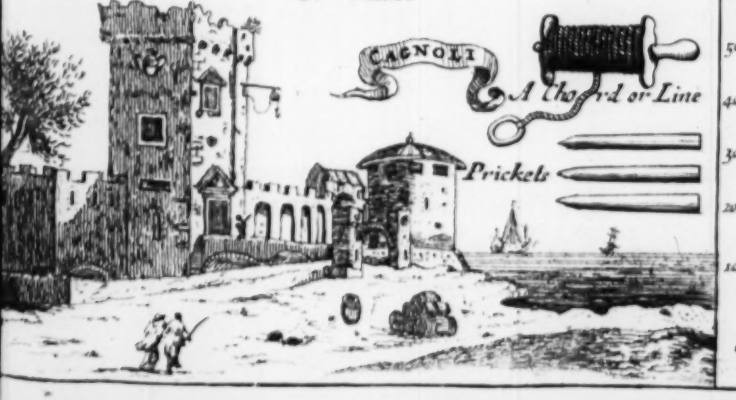


A Plain Scale

A Diagonal Scale

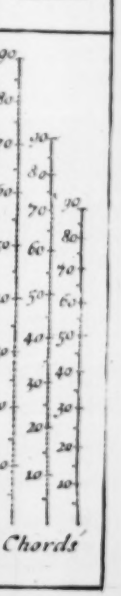


A Chaine



A Chord or Line

Prickets



Chords

or an half of the Circle is called a *Semicircle*, *a.d.b.* and always containeth 180 degrees. The quarter or fourth part is called a *Quadrant*, as *a.d.* or *d.b.* and always containeth 90 degrees or parts. And any part of the Circumference cut off by a right Line, not touching the Centre, is called a Segment or *Arch*, as *f.e.g.* and is either greater or leſs than a Semicircle, and *f.g.* is the *Cord* or ſubtenſe of that Arch, *g.e.f.*

Of right lined Figures.

A right lined Figure is a plain Surface encloſed in three right Lines or more, and are either *Triangles*, or Triangulate.

A *Triangle* is a Figure bounded with three Lines, as *Fig.* 2. and are of ſix ſorts; three in reſpect of the Sides, and three in reſpect of the Angles. 1. *Equilateral*, which hath all Sides and Angles equal, as *a.b.c. Fig.* 2. 2dly, *Iſoſcele*, or equal legged, which hath only two Sides equal, as *b.c. Fig.* 3. 3dly, *Scalene*, which hath no Sides equal, as *b.c.d.* in *Fig.* 4. 4thly, A *Right angled Figure* which hath one right Angle, as *a.* in *Fig.* 5. 5thly, An *acute angled Figure*, which hath all its Angles acute, as *o. p. q.* in *Fig.* 2. or *Fig.* 3. which are called *Oxygoniums.* 6thly, An *Obtuſe angled*, which hath one obtuſe Angle, as at *a.* in *Fig.* 4. which is called an *Amblygonium.*

An *Angle* is the corner or meeting of two Lines croſſing or interſecting one another in one Point, as at *a.* and is either Right or Oblique, *Fig.* 6. which Angle (*a*) is greater or leſs, ac-

cording as the Lines *a. b. a c.* lean nearer, or ſtand further off one from another.

A *Right Angle* is made by two right Lines touching or cutting one another perpendicularly or ſquarely, that is, when the two Angles on each ſide are equal to each other, and are always 90 degrees, as *Fig.* 7.

An *Oblique Angle* is either greater or leſſer than a right Angle, and is either obtuſe if greater, or acute if leſſer.

Here Note, That no *Triangle* can have more right or obtuſe Angles than one, for no *Triangle* upon a plain Surface can conſiſt of three greater *Angles* than ſuch as are altogether equal to a Semicircle, or two right Angles, *viz.* 180 degrees; ſo that a right Angle is always a quarter of a Circle, or 90 degrees. And the remainder of any acute Angle to 90 degrees, or any obtuſe Angle to 180 degrees is called the Complement, as if 50, then 40 is the Remainder or Complement of that acute Angle to 90; ſo if 110 for an obtuſe Angle, then 70 is the Complement to 180. For if upon the Point *c. Fig.* 8. you move a Line ſuppoſe from *b* to *f.* then it will make an acute Angle *b. c. f.* the Complement to 90. but if you move it forwards towards *d*, it is then a right Angle, or 90 degrees; *b. c. d.* for *d. c.* 90 degrees, falls right on *a. b* and makes *b. d.* equal to *d. a.* but if you move the Line further towards *e.* then is the Angle *c. b.* obtuſe, the Complement to 180 degrees, or a Semicircle. Hence it plainly appears, that let there be never ſo many Angles ſet upon one Point, as at *c.* all will be but two right Angles, *Fig.* 9. ſo alſo if two ſtrait Lines croſs one another, they make

make four Angles all equal to 360 degrees, or the whole Circle, *Fig.* 10. Note alſo, that all *Triangles* are expreſſed by three Letters, and the Angular Point by the middle Letter.

Quadrangular Figures are ſuch as have four Angles, and as many Sides, and theſe are either *Parallelograms* or *Trapezias*.

A *Parallelogram* is a four-ſided Figure bounded with parallel Lines, that is, ſuch Lines as if they were infinitely extended they would never meet, but are everywhere equally diſtant one from the other.

Rectangular Parallelograms are ſuch as have four right Angles, *viz.* the Square, and the oblong Square, as *Fig.* 11. The Square or *Tetragon* hath 4 right Angles, and 4 equal Sides. The long Square or Oblong hath four right Angles, but the Sides are unequal, as *Fig.* 12.

Obliquangled are ſuch as have oblique Angles, *viz.* two obtuſe, and two acute, of which there are two ſorts, the *Rhombus*, and the *Rhomboides*.

A *Rhombus* hath equal Sides, but no right Angles.

The *Rhomboides* hath only the oppoſite Sides and Angles equal, as in *Fig.* 13. & 14. in *Plate* 11.

All other four-ſided Figures are called *Trapezias*, which have no equal Sides or Angles, but are regularly Quadrangular, as *Fig.* 16. and may be divided into two Triangles, by drawing a Line from one Angle to the oppoſite Angle, which is called the Diagonal.

Multangular or *Multilateral Figures*, are either Regular or Irregular. Regular Multangular Polygons or Figures, take their Names from the num-

ber of their Sides or Angles, ſo a *Pentagon*, *Hexagon*, *Heptagon*, *Octogon*, *Enneagon*, *Decagon*, ſignifie a Figure of 5.6.7.8 9.10. Sides, and conſequently Angles.

Before I proceed to *Geometrical* Propoſitions, I muſt make known to the young Artiſt, That whatſoever Lines he meaſures upon Paper, or the Ground, whether by Inch, Foot, Yard, or Pole, he muſt have a *Scale* and *Compaſſes* by which the ſame meaſures may be taken off, and ſo laid down upon Paper.

Compaſſes are ſo well known, that I need not deſcribe them, only ſee they open truly on the Rivet, and be well wrought, and good Steel Points; And that they have alſo an Ink and Black Lead Point to draw Circles and Lines upon any occaſion, being very neceſſary for the projecting and laying down any Fortification.

Of the plain Scale.

Scales are of ſeveral ſorts: The *plain Scale*, which conſiſt of certain Lines divided into equal parts, upon Plates or broad Rules of Box or Braſs, is divided into great equal parts, which ſignifies Tens, and are numbred 10, 20, 30, 40, 50, *&c.* according to the length of the Lines. Again, one of theſe great Diviſions are ſubdivided into ten equal parts, and according to the number of theſe little parts contained in an Inch, 'tis made a Scale of 10, 12, 16, 20, 30, 40, 50, *&c.* equal parts in an Inch. Upon this Scale there muſt be alſo three, four, or more *Lines of Cords* to ſeveral *Radius's*, which

which are useful for many purposes in Fortification, and in other Mathematical Projections.

Of the Diagonal Scale.

A *Diagonal Scale* is made upon 11 parallel Lines equidistant, so as to include 10 equal Spaces, which are all cut at right Angles by Traverse or Diagonal Lines, dividing them all into 10 equal parts, and numbred upwards from *a. b.* which separates between the Hundreds and Tens; the Hundreds are numbred downwards, 1, 2, *&c.* to 12, if the Scale be a Foot long; the Tens are numbred upwards, with 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. which represent 10, 20, 30, *&c.* to the top where the Parallels are marked 1, 2, 3, 4, *&c.* to 10 representing Unites. So that by what hath been said, and by inspection of the Figure, the Uses will plainly appear: For suppose I would set off 169 Feet, Yards or Rods, I find first below *a. b.* 1. for 100, then 6. for 60 on the side, then for 9 at the top, and at that Intersection of 6. and 9. at *d.* and upon that parallel Line *c. d.* take that distance off with your Compasses, and set it off upon your Draught, as required.

Of Chains.

That of *Gunters* is now most in use, and contains in length four Statute Poles or Perches, each Pole containing 16 Feet and $\frac{1}{2}$, or 5 Yards and $\frac{1}{2}$, so that the whole *Chain* is 66 Feet, or 22 Yards long. This whole *Chain* is divided into 100 equal Parts or Links, whereof 25 are just a Pole or Perch,

and, for ready counting, there is uſually ſome remarkable diſtinction, by ſome Plate or large Ring at the end of every 25 Links, eſpecially at the middle of the Chain; and at the end of every 10th Link, 'tis uſual to hang ſome ſmall Curtain Ring, or ſome other diſtinction; as alſo at every 5th ſome different mark, which makes it the more ready for uſe in meaſuring.

CHAP. II.

Of Geometrical Problems.

THE Uſes of which, are to teach the ingenious Student readily to meaſure whatſoever is Quantity, Dimenſions of Bodies, Diſtances on *Sea* or *Land*, Heights and Depths of Trees, and Towers, Hills and Mountains, or the *Earth* itſelf, nay, the Heights and Diſtances of the Heavenly Bodies, *Sun*, *Moon*, and *Planets*.

Prob I. Plate 11. Fig. 1.

Of a Line, and how to draw it on Paper, or on the Ground.

A ſtrait Line is uſually drawn upon Paper with a Ruler, and by turning the Ruler end for end, as *a.* where *b.* was, you may try whether it draws a ſtrait Line or no, for then if it exactly trace or cut by a Point the ſame Line again, the Ruler is ſtrait.

Plate 2

Fig. I.

Fig. II.

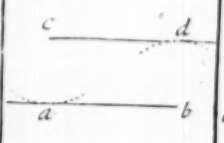


Fig. III.

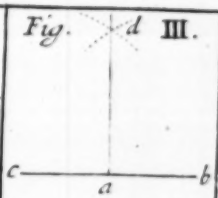


Fig. IV.

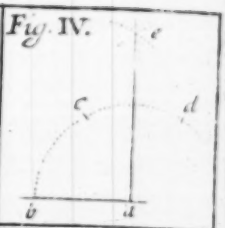


Fig. V.

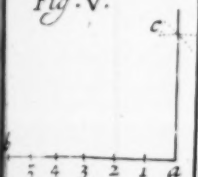


Fig. VI.

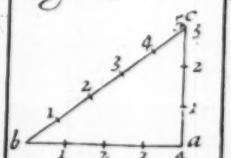


Fig. VII.

Fig. VIII.

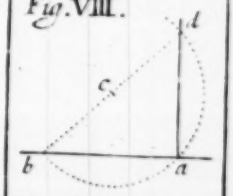


Fig. IX.

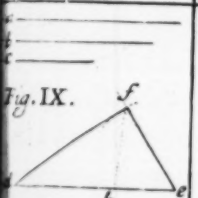


Fig. X.

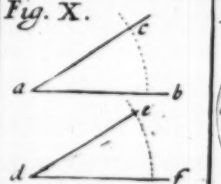


Fig. XI.

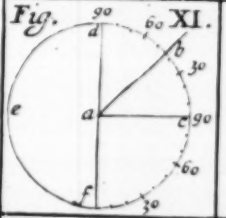


Fig. XII.

Fig. XIII.

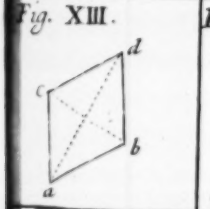


Fig. XIV.

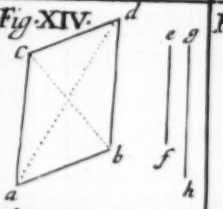


Fig. XV.

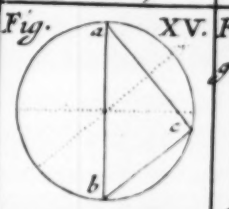


Fig. XVI.

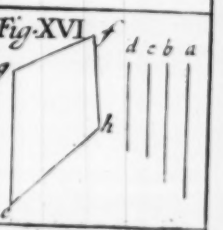


Fig. 19.

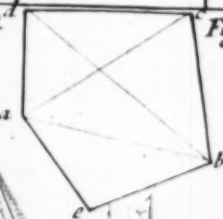
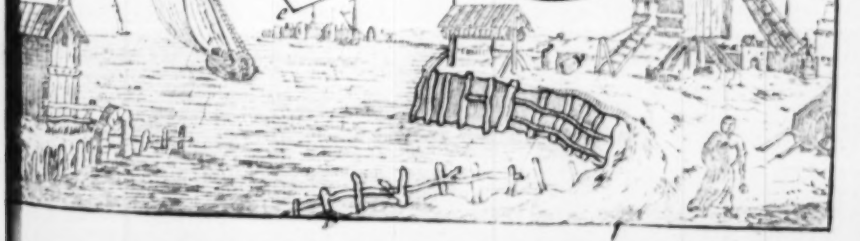


Fig. 18.



ſtrait. To draw a ſtrait Line upon the ground if level, as between *a.* and *b.* ſet up ſome marks or prickets, as *c.* and *d.* ſo as they may cover or be in a right Line, with *a. b.* ſtanding at *a.* and ſo by them or more, if need be, with a Line or Chain one length after another, you may mark out the Line *a. b.* But if any Hill or riſing Ground be betwixt *a.* and *b.* then muſt the two marks at *c.* and *d.* be ſo placed as to cover *b.* and from *c. b.* to cover *a.*

Prob. II. Fig. 2.

To draw a Line parallel to another, at any diſtance aſſigned.

Open your Compaſſes to the diſtance given, ſuppoſe *c.* ſet your Compaſſes in *c.* and take the neareſt diſtance to the Line *a. b.* with which ſetting one Point in any convenient part of the Line *a. b.* deſcribe the Arch *d.* to whoſe convexity if you apply a ſtrait Ruler from *c.* the parallel Line is drawn, by the ſame direction you may draw it upon the Ground, ſetting off your diſtance with the Chain, Cord, or Rod-pole.

Prob. III. Fig. 3.

To raiſe a Perpendicular upon any Line given, either upon Paper, or upon the Ground.

Suppoſe the point *a.* in the Line *c. b.* were the point aſſigned in the Line given, open your Compaſſes to a convenient diſtance, and with one Foot in *a.* mark

mark out the Points *c.* and *b.* then opening the Compaſſes ſomwhat wider, ſetting one Foot in *c.* and *b.* ſeverally deſcribe the two Arches cutting one another at the Point *d.* from which if you draw a Line to *a.* the work is done. To do this upon the Ground, take with a Line or Rule equal diſtances from *a.* to *c.* and from *a.* to *b.* then with a larger diſtance from *c.* and *b.* mark out the Point of Interſection at *d.* or it may be done by a Quadrant, or other Inſtrument with ſights, placing the beginning of the Inſtrument upon the Line *c. b.* and turning the ſights to 90 degrees, that Line will be perpendicular.

Prob. IV. Fig. 4.

To raiſe a Perpendicular at the End of a Line.

On the Point *a.* as a Centre, deſcribe part of a Circle *b. c. d.* with that diſtance mark out the Point *c.* from *b.* then ſetting one Foot in *c.* make a Point at *d.* upon which Points *c. d.* croſs an Arch at *e.* then lay a ſtrait Ruler from *a.* to *e.* which is the Perpendicular. Or in caſe you cannot conveniently come to make a point at *d.* then deſcribe the arch *b. c.* and with that diſtance mark out the Point *c.* as before, then lay a Ruler from *b.* to *c.* and croſs the Arch at *e.* at which Interſection a ſtrait Line or Ruler to *a.* is a Perpendicular. Or laſtly, divide *a. b.* into five equal Parts, and taking 4 of them with your Compaſſes, ſet one Foot in *a.* and deſcribe an Arch at

at *c.* then take the diſtance from *a.* to 5, and placing one Foot in 3, with the other croſs the Arch at *c.* at which Interſection a ſtrait Ruler laid to *a.* will be a Perpendicular, as *Fig.* 5.

After this manner you may raiſe a Perpendicular on the Ground by the Foot-Chain, ſetting off 40 Foot from the Point *a.* to *b.* then ſetting off 50 Foot from *b.* to *c.* and 30 Foot from *a.* to *c.* is the Perpendicular for 5, 4, and 3, deſcribe a right angled Triangle, *Fig.* 6.

Prob. V. Fig. 7.

To let fall a Perpendicular from any Point aſſigned.

With your Compaſſes ſet one Foot in *a.* and deſcribe the Arch *b. c.* again with that diſtance upon *b.* and *c.* croſs an Arch, as at *d.* ſo a ſtrait Line from *a.* to *d.* will be the Perpendicular required.

Another way, as at *Fig.* 8. towards the end of a Line, as at *d.* draw the Line *d. b.* which divide in half at *c.* then with that diſtance draw the Semicircle *d. a. b.* cutting the Line at *b. a.* in *a.* ſo ſhall a Line from *b.* to *a.* be the Perpendicular required.

Note, That all theſe Problems may more eaſily be performed by help of a ſmall Square exactly made, or with any Quadrant, by applying one Leg of ſuch a Square or Quadrant to the Line given, you may by the other Side or Leg that toucheth the Point, draw the Perpendicular.

Prob.

Prob. VI. Fig. 9.

Any three Lines given, to make a Triangle of them.

Let the Lines given be *a. b. c.* with your Compaſſes take the length of the Line *a.* and ſet it off from *d.* to *e.* ſo alſo the Line *b.* and ſet one Foot in *d.* and deſcribe the Arch at *f.* then take the length of the Line *c.* and with that diſtance ſet one Foot in *e.* and croſs the Arch made before at *f.* then from that Interſection draw the Line *e. f.* the Triangle is finiſhed.

Note, That if all the Sides, or two of them be equal, the method is the ſame; and by this direction you may draw any *Trapezium*, the Diagonal and Lines being given.

Prob. VII. Fig. 10.

An Angle given, to make another equal to it.

Let the Angle given be *b. a. c.* firſt take off the length of *a. b.* and ſet it off as *f. d.* and deſcribe the Arch *f. e.* upon the Point *d.* then taking the diſtance *c. b.* ſet it off from *f.* to *e.* ſo a Line drawn from *d.* to *e.* will make the Angle *e. d. f.* equal to the Angle *b. a. c.*

Here Note, That in the equality or inequality of Angles, we never regard the length of the Lines; for that is the greateſt Angle, whoſe Lines are further diſtant one from another at the ſame diſtance from the angular Point, or Interſection of the two Lines.

Prob.

Prob. VIII. Fig. 11.

To meaſure an Angle.

Every Angle is meaſured by that Arch of a Circle deſcribed on the angular Point, *viz. a.* is the angular Point of the Triangle *b. a. c.* and *b. c.* is the arch or meaſure of it. Now every Circle is ſuppoſed to be divided into 360 degrees, every degree into 60 minutes, *&c.* therefore the arch *b. c.* muſt be ſo many degrees and minutes of the whole Circle *b. c. d. e. f.* which to meaſure, you muſt have a Circle or Semicircle, called a Protractor. Or by a line of Cords, by either of which you may thus meaſure the Angle, *viz.* let the Angle be *b. a. c.* place the Centre of your Circle or Protractor ſo on the Point *a.* that the beginning thereof may lie on the Line *a. c.* ſo ſhall the number of degrees interſected between *b.* and *c.* be the meaſure of the Angle, which here is 45 *d.* for *c. d.* is 90 degrees, or a quarter of a Circle, and *c. b.* is half of it. If you uſe the line of Cords, you muſt take off 60 degrees with the Compaſſes, and deſcribe the arch *b. c.* then take the diſtance *b. c.* with your Compaſſes, and that diſtance applied to the Scale, will give the meaſure of the Angle *b. a. c.* 45 degrees, as aforeſaid.

Prob. IX. Fig. 12.

To make a true Square upon any Line given.

Let the Line given be *a. b.* upon one end, as at *a.* raiſe

raiſe a Perpendicular, as *a. c.* then take the length of *a. b.* with your Compaſſes, and with one foot in *a.* ſet off that diſtance to *c.* upon which point, and at the ſame diſtance, croſs an arch at *d.* and with that ſame diſtance ſet one foot in *b.* deſcribe an arch croſſing the other, from which Interſections a Line drawn to *d.* and to *b.* finiſh the Square *a. b. c. d.* The ſame direction will ſerve to make a long Square, the length and breadth being given.

Prob. X. Fig. 13.

To make a Rhombus, one Side being given.

If the Angles be not limited, draw any Angle at pleaſure, and let the Line given be *a. b.* which being taken with your Compaſſes, ſet it off from *a.* to *c.* equal to *a. b.* then with the extent of *a. b.* upon the point *c.* croſs an arch at *d.* in like manner at *b.* deſcribe another arch, croſſing the other at *d.* at which Interſection draw the Line *d. b.* and *d. c.* Note, If any Angle be given with the Side to limit the Content, you muſt ſet off the Angle by *Prob.* and then ſet off the Lines as directed.

Prob. XI. Fig. 14.

To make a Rhomboides, the Sides being given.

If neither the Angle nor Diagonal be given, then make any Angle, as here *b. a. c.* then ſuppoſing if the Lines given be *f. e. h. g.* ſet the length of *g. h.* upon *a. c.* and *f. e.* on *a. b.* then with that extent

extent of the Compaſſes, ſet one foot in *c.* and make an arch at *d.* then take the length of *g. b.* and with your Compaſſes one foot in *b.* croſs the arch made before at *d.* from which Interſection draw Lines to *b.* and *c.* and finiſh the *Rhomboides.*

Prob. XII. Fig. 16.

To make a Trapezium, *the Diagonal and Lines given.*

The Diagonal is a right Line, paſſing through the midſt of any Figure from one oppoſite Angle to another, and dividing it into two equal Triangles, which Line let be *e. f.* whoſe Sides are the Lines *a. b. c. d.* with your Compaſſes take the length of the Line *a.* and place one foot in *e.* and with the other deſcribe the arch at *g.* then take the length of the Line *b.* and with one foot in *e.* deſcribe the arch at *h.* then taking the length of the Line *c.* with one foot in *f.* croſs the arch at *g.* and taking alſo the length of the Line *d.* in the point *f.* croſs the arch at *h.* ſo ſhall Lines drawn from thoſe Interſections, make the *Trapezium* required *e. f. g. h.*

Prob. XIII. Fig. 15.

Any three Points given, how to deſcribe a Circle that ſhall paſs through them.

Any three Points make a Triangle, as *Fig. a. b. c.* therefore to draw thoſe three Points into a Circle, is but to cut any two Sides *d. b.* or *d. c.* into two equal

equal parts by *Prob. III.* and draw the ſtrait Lines; for at the point of their Interſection, as at *d.* is the Centre where the foot of the Compaſſes muſt be ſet in, to deſcribe the Circle that will paſs through thoſe three Points.

Of the Meaſure of Lines.

The common Meaſures uſed in *England* are expreſſed in the following Table from one Inch to a Mile, both in long Meaſure, and in ſquare Meaſure.

And here it will be very requiſite to know,

Firſt, That Timber, Stone, Earthwork, as Gardens, Alleys, Board, Glaſs, *&c.* are meaſured by the Foot.

Secondly, That Lands, Woods, Brickwork, *&c.* are meaſured by the Perch or Pole.

Thirdly, That Pavings, Plaiſterings, Wainſcotings, are meaſured by the Yard. All linen and woollen Cloth, Stuffs, Silks, *&c.* are by the Yard Ell.

Fourthly, Carpenters Works, as Flooring, Partitioning, Roofing, Tyling, the Ground-plot of Houſes and whole Buildings, are meaſured by a Rod of 10 foot long. That, every way laid out or multiplied by itſelf, is called a Square, containing 100 ſquare feet.

A Ne-

A Neceßary Table for Menſura of Superficiall Meaſures

	Inches.	Centeſme.	Feet.	Yard.	Pace.	Pearch.	Chain.	Acre.	Mile.
Inche.	1	7. 92	12	36	60	198	792	7920	63360
Centeſm.	62726	1	1. 515	4. 56	7. 575	25	100	1000	8000
Feet.	144	2. 295	1	3	5	16. 5	66	660	5280
Yard.	1296	20. 755	9	1	1. 66	550	22	220	1700
Pace.	3600	57. 381	25	2. 778	1	3. 3	13. 2	132	1056
Pearch.	39204	625	272. 25	30. 25	10. 89	1	4	40	320
Chain.	627264	10000	4356	484	174. 24	16	1	10	80
Acre.	6272640	100000	43560	4840	1742. 4	160	10	1	8
Mile.	4014489600	64000000	27878400	3097600	1115136	102400	6400	640	1
Square.	Inches.	Centeſme.	Feet.	Yard.	Pace.	Perch.	Chain.	Acre.	Mile.

Long Meaſur.

Of meaſuring of Superficies.

Firſt, To meaſure or find the ſuperficial Content or *Area* of any right lined Figure, you muſt firſt know, that as there is in a Foot 12 Inches, ſo 12 times 12. or 144 ſquare Inches, is a Foot ſquare; ſo alſo as there is 3 Foot in a Yard, there are 3 times 3, *viz.* 9 ſquare Feet in a Yard ſquare, and ſo of the other parts of Meaſure, as in the foregoing Table.

Prob. XIV.

To find the Content of any Triangle.

Secondly, The Content of all Triangles, whether right, acute, or obtuſe angled, is found by multiplying the whole Baſe of the Triangle by half of the Perpendicular let fall upon the Baſe, or the whole Perpendicular by half the Baſe.

Thirdly, That all right lined Figures, whether

alone, or as parts of 4, 5, 6, or more ſides, may be reduced to Triangles, and by adding up the Contents of all the ſeveral Triangles, their Content found out by the general Rule aforeſaid, which therefore ought to be remembred. To make this plain, being of ſo general uſe, I ſhall make one Example, *viz.* ſuppoſe in *Fig.* ix. *d. e.* the Baſe of the Triangle is 44 Feet, and the Perpendicular *f. b.* to be 20. Now whether you multiply the whole Baſe *d. e.* 44, by half the Perpendicular *f. b.* 10. or multiply 20. the whole Perpendicular by 22. the half of the Baſe, the Product gives the Content 440 Feet, for the ſuperficial Content or *Area* of that Triangle.

Prob. XV.

To find the Content of a Square, or Oblong Square.

Multiply the Length by the Breadth, the Product gives the *Area* or Content, Example *Fig.* xii. let the *Square* be

17 Inches length
17 Inches breadth

289
17

289

multiply one ſide by the other, the Product is the number, *viz.* 289 ſquare Inches contained in that Square, ſo alſo ſuppoſe *Fig. xiii.* one ſide to be 25, the other ſide 13 which multiplied together produceth 325 ſquare Feet.

13
25

65
26

325

Prob.

Prob. XVI.

To find the Area, *or Content of a* Rhombus *or* Rhomboides.

Let fall a Perpendicular from one of the obtuſe Angles upon the oppoſite ſide, that ſide multiplied by the Perpendicular, gives the *Area*, *Fig.* xiii. the ſide *d. b.* 20 yards, the Perpendicular 14 give 280 ſquare yards. For the *Rhomboides* divide it into two Triangles by a diagonal line drawn between either pair of the oppoſite Angles, as *a. d.* in *Fig.* 14. then from the oppoſite Angles either at *c.* or *b.* let fall a Perpendicular upon that Diagonal, as *b. o.* then multiply the length of the Diagonal by the Perpendicular *b. o.* and then you have the *Area*.

20
14
80
20
280

Example: Suppoſe the { Diagonal 19 Rods. / Perpend. 5 / Content 95

Prob. XVII.

To find the Content of a Trapezium.

Divide it into two parts from Angle to Angle, as *Fig.* 16. is divided by the Diagonal *e. f.* then from the other two Angles, *viz. g. b.* let fall Perpendiculars upon the Diagonal. The ſum of half the length of thoſe Perpendiculars being multi-

plied by the ſum of the length of the Diagonal, or common Baſe, gives the ſuperficial Content.

Example: Suppoſe the Diagonal *e: f.*	33	chains.
the Perpendicular *g.*	15	
the Perpendicular *h.*	13	
The Sum of both Perpendic.	28	
the half Sum	14	
Being multiplied by the Diagon.	33	
	42	
	42	
The Content or *Area*	462	

Of Foreign Meaſures.

The Foreign Meaſures moſt made uſe of in Fortification, are the *Pariſian*, *Rhineland*, and *Venetian* Feet, which, in proportion to the *Engliſh* Foot, divided into 1000, are as followeth:

Pariſian	*Rhineland*	*Venetian*
1.1068	1.1033	1. 1152
2.2136	2.2066	2. 2304
3.3204	3.3099	3. 3456
4.4273	4.4133	4. 4608
5.5340	5.5166	5. 5768
6.6408	6.6919	6. 6912
7.7477	7.7233	7. 8064
8.8546	8.8266	8. 9216
9.9613	9.9299	9.10368

The uſe of theſe Tables are plain and eaſie, in ſhort thus: Suppoſe I would know how many *Engliſh* Feet are equal to 755 *Venetian*, againſt which I find 700 — 8064; 50 — 576; 5 — 057; which added together, is — 8697

And

And the laſt Figure cut off, gives you 869 *Engliſh* Feet equal to 755 *Venetian*. Or if you ſay by the Rule of Three, If 1000 *Engliſh* Feet give 1152 *Venetian*, what ſhall 755. multiply and divide, and you will find 869, as before. Thus you will find 985 *Pariſian* Feet to make 1052 *Engliſh*.

Example:

900	9613	Or if 1000 require
80	854	1068, what ſhall 985,
5	53	which multiplied and
		divided, gives 1052, as
985	1052lo	before.

Here Note, That the *Engliſh* Rod or Pole is 16 Foot and an $\frac{1}{2}$, but the Rod of 10 Foot is beſt for uſe. That the *French* reckon by the *Toiſe*, which is 6 of their Feet for a Meaſure in Fortification. The *Venetian* account by the Pace, which is 5 of their Feet. The *Dutch* by the Rod of 12 of their Feet.

Prob. XVIII.

To find the Content of a Regular Polygon.

Draw a Line from the Centre to the middle of any ſide, half of the Perimeter (or half of the ſides,) being multiplied by that Line, gives the Content.

Example: Admit the *Polygon* be the *Hexagon* in *Fig* 18. whoſe ſides are 700 Feet, 6 times 700 is 4200. the half of which is 2100, which multiplied by the Perpendicular, which is 602, gives 1264200 Feet for the Content of the *Polygon*.

This Eſtimate being only in ſquare Feet, will want a Reduction to a higher Denomination, I have therefore, for ſuch like Caſes, added the Table of Square Meaſure, by which you may, by Inſpection, find out any Denomination.

Example: Suppoſe I would reduce the aforeſaid Number into Acres, I therefore look into the Table, and find Feet in the top, and Acres on the ſide, and in the Column anſwering thereunto, I find 43560 Feet to make one Acre, I therefore divide 1264200 by 43560, the Product whereof is 28 Acres, and 4510 Feet, which by the ſame way I find to be 1 Chain, and 164 Feet, the Content of the *Polygon* required.

Prob. XIX.

To find the Content of an Irregular Polygon.

Divide it into *Trapezia's* and Triangles by Diagonals, then find their Content ſeverally, and ſum up altogether.

Example: Suppoſe *Fig.* xix. an irregular *Polygon* divided into 3 Triangles by the Lines *a. b. a. c.* and *d. b.* whereof two of them being upon the ſame Baſe *d. b.* make up a *Trapezium*, whoſe Content may be found, as was taught in *Prob.* 17. then there remains the Triangle *a. e. b.* whoſe Content may be found by *Prob.* 14. then adding the Content of the *Trapezium* to the Content of the Triangle, you have the *Area* or Content of the whole *Polygonian* Figure.

Come we now to the Art of Fortification.

CHAP.

CHAP. III. Plate III.

The Diviſion of Fortification.

FOrtification, or Military Architecture, is a Science how to defend and fortifie any Place, ſo that all parts of it may mutually defend and aſſiſt each other againſt the Force of an Enemy.

The Diviſion of Fortification.

The whole Art is divided into eight Parts, viz. *Defenſive*, *Offenſive*, *Natural*, *Artificial*, *Ancient*, *Modern*, *Regular*, and *Irregular*.

Defenſive Fortification ſhews how a Place is to be defended againſt all Force and Violence of an Enemy.

Offenſive Fortification ſhews how to Beſiege, and take a Fortified Place.

Natural Fortifications have theſe Advantages, they cannot eaſily be undermined, they are naturally ſtrong, difficult to be ſcaled, may be built up with ſmall Charge, and are moſt eaſie to be defended.

In *Artificial Fortifications* there ought to be conſidered the ſituation of a Place, the nature of the Earth, the condition of the adjacent Country, and the Figure.

Ancient Fortification was plain and rude, as all Beginnings are wont to be. At firſt Walls were raiſed to ſuch a Height, as might keep off the Enemy from an eaſie Aſcent by Ladders, and Loop or Port-holes were made in the Wall. Afterwards they added to the Walls a Breaſt-work, the Top whereof was left open at certain Diſtances, ſo that covered with their Battlements they might defend themſelves, and through thoſe Intervals beat off the Enemy After this were made round Terrets or Towers to cover the Walls, and to add more ſtrength to them.

Modern Fortification is that way of Defence which is now uſed, turning the Walls into Ramparts, the round Towers into Bulwarks, fitted with Face and Flank, and encloſing the whole with right or ſtrait Lines, ſo that all parts of the Fortification ſecure and defend each other.

Regular Fortification is, when a Place or Town hath equal Sides or Angles.

Irregular Fortification is, when a Place hath unequal Sides, and unequal Angles.

CHAP. IV. Plate IV.

A further Definition of Fortification.

FOrtification is alſo divided into three principal Parts, viz. *Ichnographie*, *Orthographie*, and *Scenographie*.

Ichno-

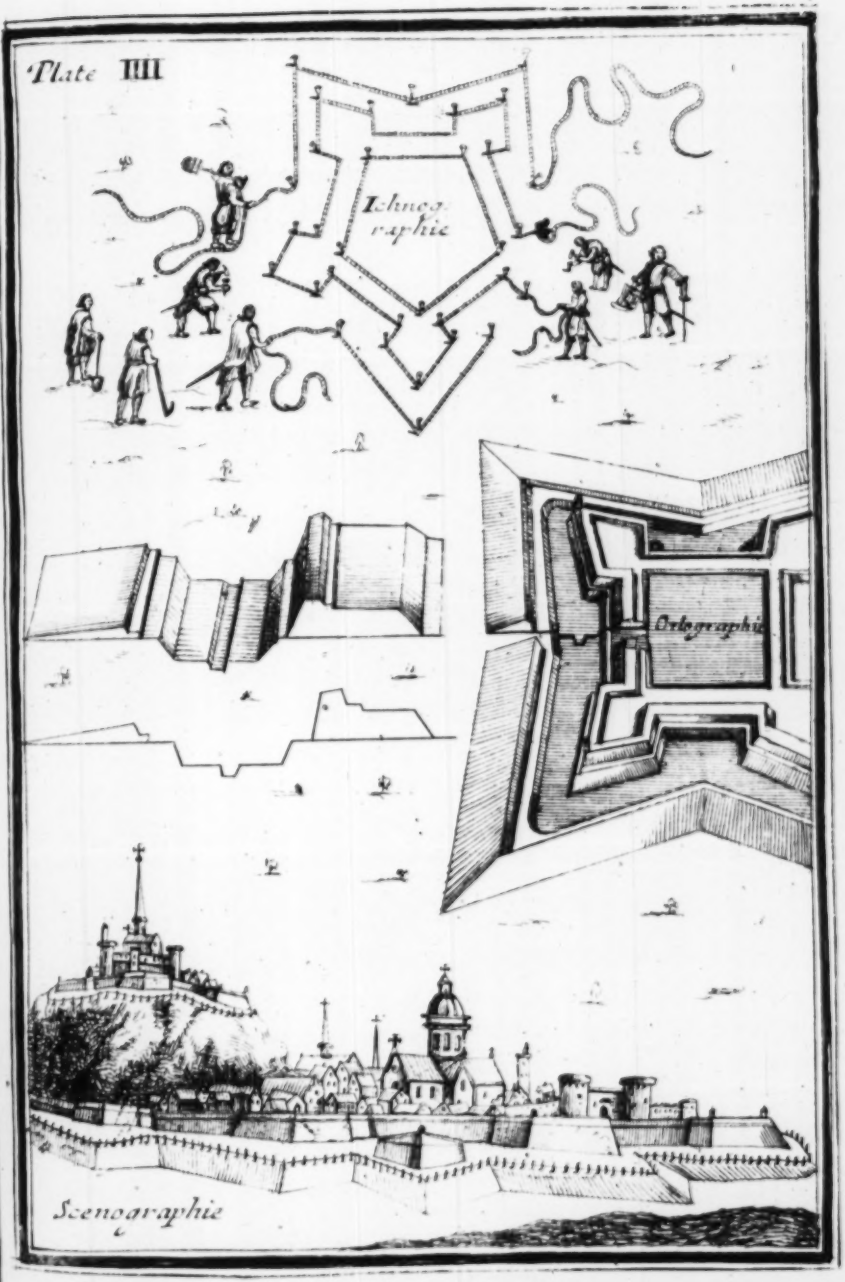
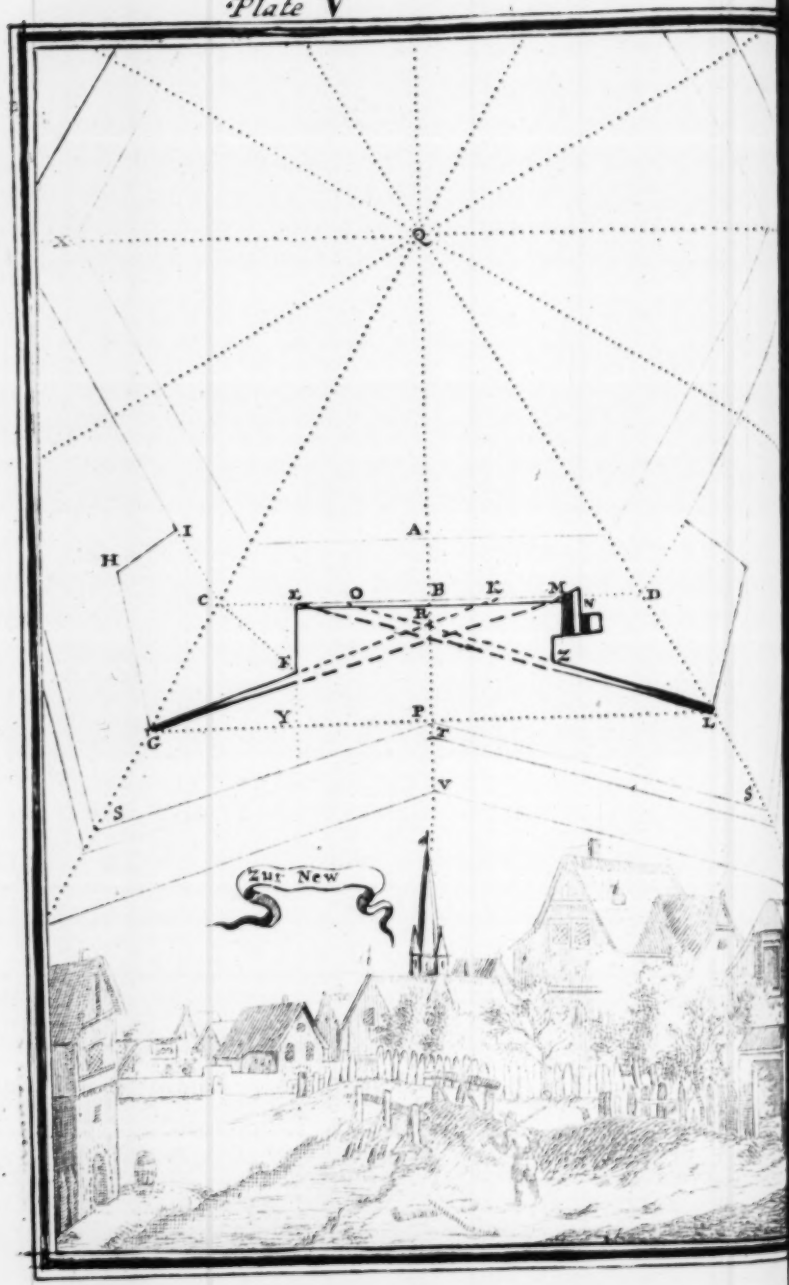


Plate IIII
Ichnog-
raphie
Orthographie
Scenographie

Plate V



Ichnographie is a Repreſentation or Ground-plot of any Fort or other Work either made, or to be built, drawn or delineated on Paper, ſhewing and deſcribing its Form and Proportion, with all its Lines and Angles, and all other parts belonging to it.

Orthographie, or *Profile*, is a perpendicular or upright Draught of any Fortification as it doth preſent itſelf to the view being finiſhed, ſhewing all the Breadths, Heights, Depths and Lengths of the Rampart, Parapet, Ditch, or Covert-way, *&c.*

Scenographie is the Model or Draught of any Work preſented with its ſhadows, according as the Work itſelf ſhews with its Dimenſions according to the Rules of Proſpective, all which will more plainly appear to the underſtanding, by *Plate* IV.

CHAP. V. Plate V.

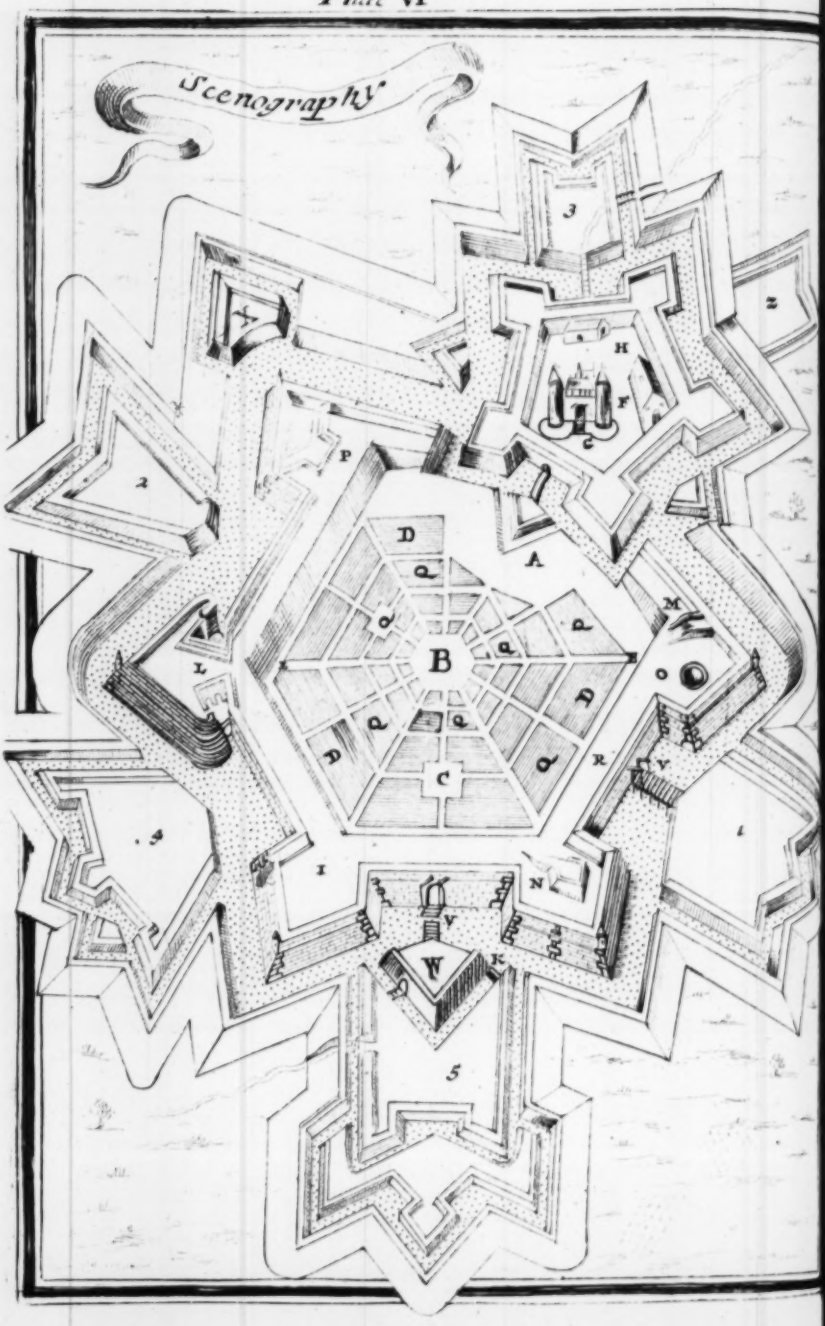
The Definition of the principal Lines and Angles in the Ichnography, *according to the* Latin, French, *and* Engliſh.

THE principal Line to be regarded in all Fortifications, is the outward or exterior Line bounding the Rampire, at the Foot next to the Ditch, from which Baſis all the reſt of the Lines depend.

Latin.

	Latin.	French.	Engliſh.
GFEBMZL	*Vallum & Munimen.*	*Rampart.*	*Rampire.*
E M	*Cortina & Chorda.*	*Courtine.*	*Curtain.*
M. z or E F	*Ala propugnaculi.*	*Flanq ou le Flanc.*	*The Flank.*
C E	*Collum.*	*La demi gorge.*	*The Gorg or Neck.*
C B	*Capitalis.*	*Capitale.*	*The Capital.*
Gm or E L	*Linea defenſionis figens.*	*Ligne de deffenſe Fichante.*	*The fixed Line of Defence.*
GK or L O	*Linea ſtringens.*	*Ligne raſante, ou Flanquente.*	*The flanking Line of Defence, or Line ſtringent.*
E O	*Ala Cortinæ.*	*Second Flanc, ou Flanc oblique.*	*Second Flank.*
G F	*Facies propugnaculi.*	*La Face.*	*The Face.*
z o or F K	*Liberum ſtringentis.*	*Face prolongee.*	*The Face prolonged.*
F y	*Alæ continuatio.*	*Flancq prolongee.*	*The Flank prolonged.*
E F G H I	*Propugnaculum vel munitio.*	*Baſtion, ou Boulevart.*	*A Bulwark, or Baſtion.*
C D	*Latus Arcis.*	*Coſte du Polygone interieur.*	*The inward Polygon.*
G L	*Latus multanguli exterioris.*	*Polygone exterieur.*	*The outward Polygon.*
Q D or Q C	*Radius Caſtri.*	*Le petit Demidiameter.*	*The little Semidiameter.*
Q L or Q G	*Radius multanguli exterioris.*	*Le grand Demidiameter.*	*The great Semidiameter.*
C Q D	*Angulus Centri.*	*Angle du centre.*	*Angle of the Centre.*
C D X	*Angulus Figuræ.*	*Angle Polygone.*	*Angle of the Figure, or of the Polygon.*
H G F	*Angulus propugnaculi, & Angulus defenſus.*	*Angle Flanque, ou Angle du Baſtion.*	*Angle of the Baſtion.*
E K For m o z	*Angulus alæ ſubtenſus ſive angulus ſtringentis & Cortinæ.*	*Angle Flanquant interieur.*	*The Angle of the Curtain, and flanking Line of Defence.*
E F K or m z o	*Angulus ſubtenſus complemento Cortinæ, ſive Angulus ſtringentis & alæ.*	*Angle de la Flanquante & du Flancq.*	*The Angle of the Flank, and flanking Line of Defence.*

Plate VI



	Latin.	French.	Engliſh.
GFE or mzl	*Angulus Faciei & Alæ.*	*Angle du Flancq & de Face, ou Angle de l'Eſpaule.*	*Angle of the Face and Flank.*
G R L	*Angulus decuſſationis, vel Angulus defendens.*	*Angle de Tenaille, Angle flancquant exterieur.*	*Angle of the Tenail.*
E C F or	*Angulus determinans Alam.*	*Angle Forme Flancq.*	*Angle forming the Flank.*

Note alſo, that *A. B.* is the Baſe of the Rampire, *B. P.* the breadth of the Ditch or Moat, *B. R.* the Eſcarpe or Slope of the Ditch next to the Wall, *S.P.S.* is the Contraſcarpe, that is, the ſloping of the Moat contrary to the Eſcarpe, *P. T.* is the Covert or cloſe way which is left above the Moat next the open Field, *T. V.* is the *Glacis* or Eſplanade, a kind of Parapet which loſeth itſelf inſenſibly, level with the Earth, *M. N.* Cazemates or Retreats made in the Flank to fire upon the Enemy.

Of the general Parts of Fortification. *Plate* VI.

The whole Art of *Fortification* is principally comprehended in two general Parts, the firſt of *Defence*, the ſecond of *Offence*.

The *defenſive* part ſhews how a Place is to be defended againſt the force and violence of an Enemy, and conſiſts chiefly in theſe five following Parts.

1. In the principal Works of a place, which are *Bulwarks*, and the *Curtain* between them, *&c.*

2. In

2. In the Outworks, which are the *Moat* or *Ditch*, the *Ravelins*, *Half-Moons*, *Tenailes*, *Horn* and *Crown-Works*, &c.

3. In the inner Buildings, which are the *Armories*, *Magazines* or *Store-houſes*, *Corp de Gards*, *Bridges*, *Mills*, *Houſes*, &c.

4. In the accidental Works, which are *Retrenchments*, *Counter-approaches*, *Countermines*, &c.

5. In the Gariſon, or ſufficient number of Men, with the *Ammunition*, *Arms* of all ſorts, great and little *Guns*, with all other Stores and Proviſion whatſoever. All which are repreſented in *Plate 6. viz.*

A. is a City or Town.
B. the Magazine, Storehouſe, or place of Rendezvous.
C. The Market-place.
D. The Ground-plot of the Houſe.
E. The Streets.
F. The Cittadel or Caſtle.
G. The Governor's Houſe.
H. The Hutts or Lodgments of the Soldiers.
I. Is a Baſtion or Bulwark.
L. Is a Baſtion with Cazemates, with the Port-holes or Embrazures.
M. A Platform.
N. A Cavalier.
O. Is a Contramine.
P. Is a Retrenchment.
Q. Repreſents the great Buildings, *viz.* Churches, and other publick places.
R. Is the Rampire with its Parapets, *&c.*
S. Is the Ditch or Moat.

T. The

T. The Foreland, Barm, Liſire, or Cordon by M. *Mallet.*

V. The Bridge.

W. Is a Ravelin.

X. Is a Half-moon.

Z. Is a ſingle Tenaile; 1. is a double Tenaile; 2. is a Swallow Tail, *Ouvrage a Quevé Ironde*, in *French*; 3. is an Hornwork; 4. is a Crown-work; 5. is a Crowned Horn-work; all which Parts we ſhall more particularly explain in the following Diſcourſe.

CHAP. VI.

Of the general Canons and ſpecial Rules which are to be obſerved in all Fortifications.

IN fortifying any Place, there is to be obſerved theſe ſix following Parts, *viz.*

1. The *Defence.* 2. The *Offence.* 3. The *Earth.* 4. The *Nature* or *Situation* of the Place. 5. The *Nature* of the adjacent Country. 6. The *Form* or *Figure.*

For defending a Place, obſerve theſe following Rules in the *Ichnography.*

Firſt,

First, The *Form* of a *Fort* muſt be ſuch, that all its Parts may *flank* and be *flanked*, that is, defend one another.

Secondly, The *Fichant* or *fixed Line* muſt not exceed a Muſquet-ſhot. The beſt Proportion, ſaith *Taquet*, will be 750 or 720 Feet. Sir *Jonas Moor* ſaith, The Line of Defence fixed, or which is near equal to it, *viz.* the inferior *Polygon* muſt not be longer than 800 Feet, nor ſhorter than 500. *Borcklern* ſaith not under 60, and not above 70. *Rhyneland* Perches, *Travaux de Mars* 120 *Toiſes*.

Thirdly, The *Baſtion* or *Bulwark* muſt not be too great nor too little, but ſuch as may receive a ſufficient number of Men, and afford room enough for the traverſing Guns, and performing other Military Duties.

Fourthly, The *Angle* of the Bulwark muſt not be leſs than 60 degrees, nor much more than 90; for if it be too ſlender, 'tis eaſily batter'd by the force of the Cannon; if too obtuſe or blunt, 'twill be the ſooner beat open at the Point.

Fifthly, The greater the *Angle* that is made by the outward *Polygon*, and the Face, the greater is the defence of the Face. And this Maxim Sir *Jonas Moor* holds ſo eſſential, that it ſhall try the goodneſs of all Inventions for what kind of *Fortification* ſoever.

Sixthly, The *Angle* of the *Flank* and *Courtain* muſt always be a right *Angle*, that ſo as well the *Courtain* as the *Face* may be the better defended, and the *Angles* of the *Face* and *Flank* be the ſtronger: But Sir *Jonas Moor* ſaith, There is no more Virtue in a *Right Angle* than in another. And the Inge-

Ingeniers of this Age leſſen the *Angle*, keeping notwithſtanding a due ſtrength for it, rather than want the *Flank* in the *Courtain:* For that *Fort*, ſaith *Taquet*, is far the ſtrongeſt, which keeping the reſt of the Maxims, hath alſo *Flanques* in the *Courtain*; And without which, *Borcklern* tells us, a *Fort* is imperfect.

Seventhly, The *Face* of a *Bulwark* ſhall not be ſhorter than the half of the *Courtain*, nor longer than the whole. The *Flank* muſt not be leſs than the 4th part of the *Face*, nor bigger than half the *Face*. And the *Gorge* or *Demigorge Line* muſt not be much longer or ſhorter than the *Flank*; in theſe three *Dogen* and *Goldman* agree.

Eighthly, In ſhort, That Form of a *Fortification* will be the beſt, that hath the largeſt *Flanks* in the *Baſtion* and *Courtain*, the *Gorge Lines* very large, the *Angle* of the *Baſtion* a *Right Angle*, or near to it, and the *Fichant Line* of Defence at moſt not exceeding a Muſquet-ſhot.

CHAP. VII.

BEfore I proceed to the laying down any *Fortification*, I ſhall ſhew how to deſcribe the *Polygons* themſelves; and firſt,

Prob.

Prob. VII. Fig. 1.

How to inſcribe any Figure *or* Polygon *within any* Circle.

Let *a. d. b. e.* be a *Circle* given, and it is required to find the ſide of

A *Regular Figure* made of	4	*Sides* or *Angles*, containing	180		Degrees or parts of a *Circle* at the Angles of their *Centre*, and deſcribeth a	*Triangle*	whoſe *Angle* at the *Figure* or *Polygon* containeth	60
	3		90			*Tetragon*		90
	5		72			*Pentagon*		108
	6		60			*Hexagon*		120
	7		51	43 1/2		*Heptagon*		128 34 1/2
	8		45			*Octagon*		135
	9		40			*Enneagon*		140
	10		36			*Decagon*		144
	11		32 8/11			*Hendecagon*		147 7/11
	12		30			*Dodecagon*		150

The Complement to 180.

Plate VII

Fig. I.

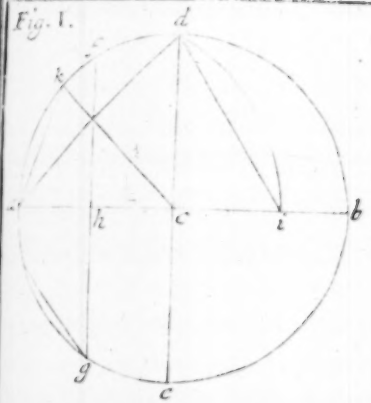


Fig. II.

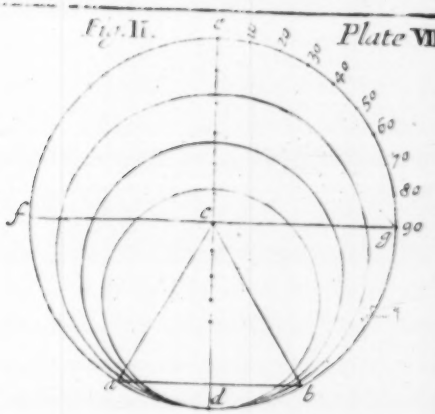


Fig. III.

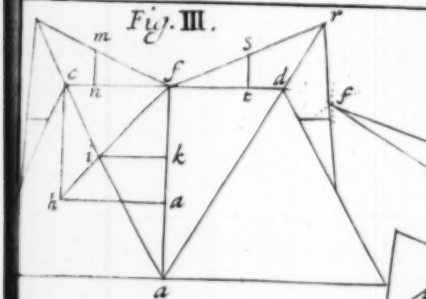
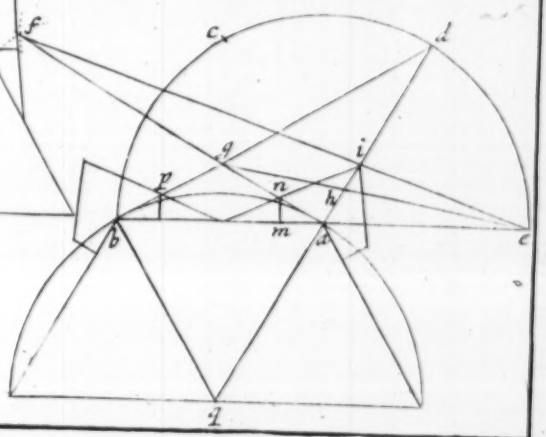
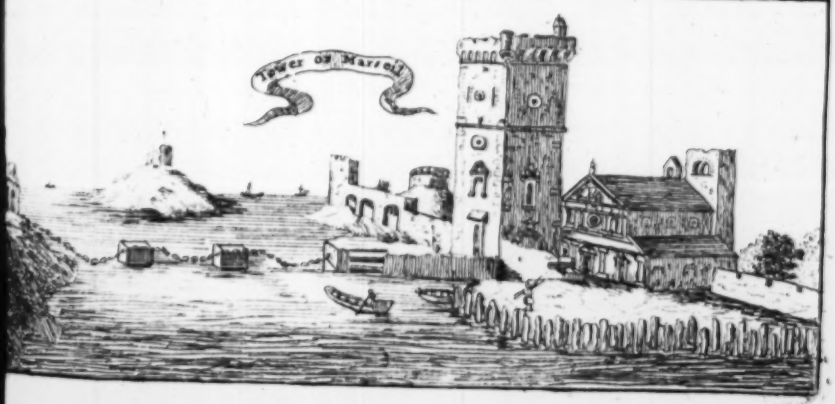


Fig. IV.





First, Through the *Centre c.* draw the *Diameter* or Line *a. c. b.*

Secondly, Take with your *Compaſſes* half the *Diameter a. c.* or *c. b.* and ſetting one foot in *a.* with the other make the marks *f. g.* and draw the line *f. h. g.* which ſhall be the ſide of a *Triangle* that will be inſcribed in that *Circle.*

Thirdly, Draw the line *d. e.* through the *Centre c.* cutting the *Diameter a. b.* at *Right Angles*, and draw the line *a. d.* which ſhall be the ſide of a *Square*, which will be inſcribed in that *Circle.*

Fourthly, Set one foot of the *Compaſſes* in *h.* and extend the other to *d.* and draw the *Arch d. i.* then draw the Right Line *d. i.* which ſhall be the ſide of a *Pentagon.*

Fifthly, Any of the *Semidiameters c. a. c. d. c. b.* or *c. e.* are the ſides of an *Hexagon.*

Sixthly, Half of the line *f. g.* viz. *h. f.* or *h. g.* are the ſides of an *Heptagon.*

Seventhly, Divide the line *a. d.* into two equal parts, as at *o.* and draw the line *c. o. k.* ſo ſhall a line drawn from *a.* to *k.* be the ſide of an *Octagon.*

Eighthly, Divide the half of the *Circle* line *f. a. g.* into 3 parts, and a ſtrait line from *g.* to one of them, *viz.* at *p.* will be the ſide of a *Nonagon*, or *Enneagon.*

Ninthly, The line *c. i.* is the ſide of a *Decagon.*

Tenthly, The half of the line *h. i.* will be the ſide of an *Endecagon*, and that diſtance *f. d.* gives the ſide of a *Dodecagone* that may be inſcribed in this *Circle.* Or any *Circle* being drawn from any *Protractor*, or a line of *Chords*; if from the ſame you take any of theſe Numbers off with your

Compaſſes, and work ſo many times as your *Figure* hath ſides, you will deſcribe the *Figure* deſigned. Or a *Right Line* drawn from each end of the Line given to its oppoſite *Side* and *Angle* at the *Interſection*, gives the *Centre* of a *Circle*, which ſhall divide it into the *Sides* of the Line given.

Prob. II. Fig. 2. Plate VII.

To deſcribe a Circle *to contain any* Polygon, *whoſe Sides muſt be anſwerable to the Line given.*

Suppoſe *a. b.* the Line given, then with that diſtance deſcribe an *Equilateral Triangle*, as by *Prob. V I.* then from the *Centre c.* in the middle of *a. b.* draw a ſtrait Line *d. e.* as by *Prob. III.* which croſs at *Right Angles* through the *Centre*, as the Line *f. g.* then at the Point *c.* and open your *Compaſſes* to *d.* and with that diſtance deſcribe the *Circle a. f. e. g. b.* then with the ſame diſtance with one foot in *e.* make a croſs at *h.* and with one foot in *g.* mark out *i.* ſo is the *Quadrant e. g.* divided into three parts, which divide again each into three more, ſo is the *Quadrant* divided into nine parts or degrees, numbred 10. 20. 30. to 90. then with one Point of your *Compaſſes* in *c.* extend the other to *g.* at 90. and ſo croſs the Line *d. e.* at 3. then open the *Compaſſes* to 80. and croſs the Line *d. e.* at 4. ſo to 70. and croſs the Line *d. e.* at 5. ſo alſo to 60. which will cut the Line *d. e.* in the *Centre c.* or 6. and ſo on to 10. and 12. ſo that each Point 3. 4. 5. *&c.* be a *Centre* to deſcribe a *Circle*, which ſhall contain a *Polygon* of ſo many *Sides* as is numbred on the ſeveral *Centres*, ma-

making the Line *a.b.* equal to the *Sides* of each *Polygon* as was required. And thus may you make any *Line of Chords* to any *Circle* or *Radius* whatſoever.

Porb. III. Fig. 3. Plate VII.

How to delineate any Regular Fortification *upon Paper*, Geometrically, *two ſeveral ways.*

Firſt, Suppoſe an *Hexagon*, whoſe *Side* or *Polygon interior* is *c. d.* upon half of which, as *c. f.* make a *Square c. f. h. g.* and draw the Lines *a. c.* and *a. d.* and draw the *Diagonal* Line *h. f.* which cuts the half *Diameter a. c.* at *i.* from which Point let fall the *Perpendicular i. k.* which is the length of the *Capital Line*, which ſet off from *c.* to *l.* and from *d.* to *r.* then draw the Lines *l. f.* and *f. r.* and from the middle thereof, as at *m.* and *s.* let fall *Perpendiculars* upon *c. d.* at *n.* and *t.* ſo is *l. c. Capital*, *l. m.* the *Face*, *m. n.* the *Flank*, *c. n.* the *Gorge*, *n. t.* the *Curtain*. This do for the reſt of the *Baſtions*, ſo ſhall the *Ground-plot* be deſcribed.

Here is to be obſerved, 1. That the diſtance between the points of the *Baſtions* in *Great Royal* are always 80 *Rods*.

2. That the *Face-line* is always the half of the Line of *Defence*.

3. That the *Flank* is half the diſtance between both *Polygons*.

4. That the *Curtain* is half of the *Exterior Polygon*.

Prob. IV. Fig. 4. Plate VII.

How to deſcribe any Regular Fortification *upon Paper* Geometrically, *with one opening of the* Compaſſes.

Upon a Line given *b. a.* find the *Centre q.* by *Prob. II.* and draw the Lines *b. q. a.* then at the end of the Line *a.* with its length *a. b.* deſcribe a *Semicircle b. c. d. e.* then with the ſame diſtance at the Points *c.* and *b.* make two *croſs Arches* to cut each other at *f.* from which *Interſection* draw a Line to *a.* and to *e.* and likewiſe from *d.* to *b.* and *a.* and alſo from *g.* to *e.* ſo is *a. b.* the length of the *Gorge*, *b. i.* the length of the *Flank. a. i.* the length of the *Capital i. n.* the length of the *Face.* all which may be ſet off upon the reſt of the *Baſtions*, and ſo may your *Figure* be finiſhed.

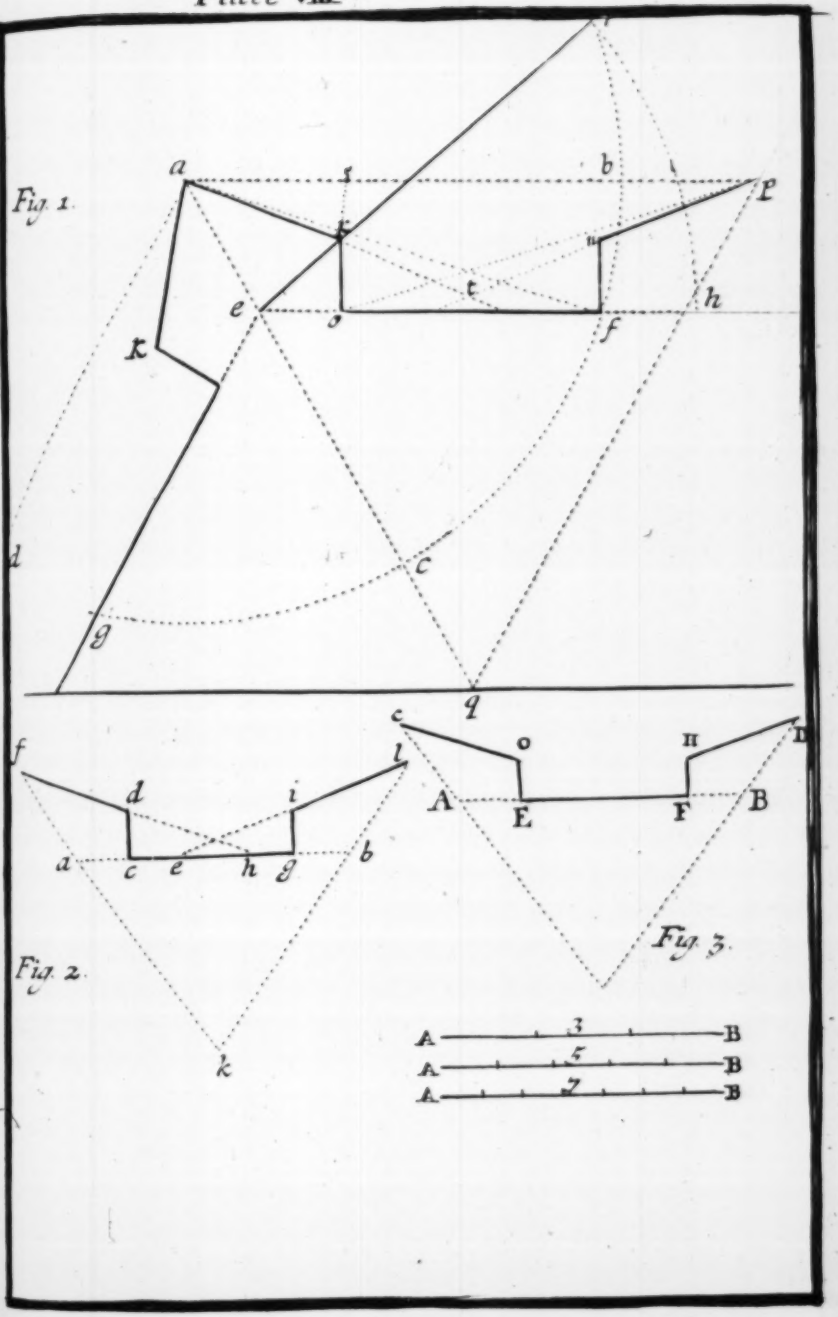
CHAP. VIII. Prob. I.

How by a Line of Chords *to deſcribe any* Fortification, *having only two* Angles *given.* Plate VIII. Fig. 1.

LET the Line given be *a. p.* upon *a.* as a *Centre*, with the *Chord* of 60 degrees taken from your *Scale*, deſcribe the *Arch b. c. d.* then from *b.* ſet off half your *Polygon Angle*, which

you

Plate VIII



your *Fort* be an *Hexagon*, as here you will find it in the Table in *pag.* 32. to be 120. the half whereof is 60 degrees, which ſet off from *c.* to *f.* and from *c.* to *g.* and draw the Lines *a. b.* and *a. d.* then take off the diſtance of ⅓ part of the half *Polygon Angle*, *viz.* 20 degrees from the *Line of Chords*, and ſet it from *a.* to *e.* the length of the *Capital.* then draw the Line *e. f.* parallel to *a. b.* which ſhall be the inward *Polygon.* Then upon the Point *e* with the *Chord* of 60 degrees, deſcribe the *Arch h. r.* then ſet off 40 degrees for the *Angle*, forming the *Flank* from your *Line of Chords*, and ſet it off from *h.* to *r.* then draw out the Lines *e. r.* and *a. f.* ſo ſhall the *Interſection* at *k.* mark out the Face of the *Baſtion*, then from *k.* let fall a *Perpendicular k. o.* which ſhall be the *Flank*, and *e. o.* the *Gorge*, and *o. f.* for the *Courtain.* Or let *a. p.* be the *angular Point* of two *Baſtions.* On the *Point a.* deſcribe the *Angles q. a. p.* and *p. q. a.* which in this Figure of an *Hexagon* is 60 degrees, as the *Arch b. c.* then take half the *Angle* of the *Baſtion*, which here is 40. and ſet it from *c.* to *f.* then draw the Line *f. e. parallel* to *a. p.* and proceed, as before directed. The reſt of the *Baſtions* may be ſet off from this, and ſo finiſh your Work.

Prob. II. Fig. 1. Plate VIII.

How to find the Angles *of any* Fortification.

The *Angle* of the *Centre e. q. h.* is found, by dividing 360 degrees by the number of its ſides, as 360. by 5. gives 72. for a *Pentagon.* 360. by 6. gives 60. for an *Hexagon*, &c. The *Angle* of the

Figure or *Polygon h. e. g.* is found by ſubſtracting the *Angle* of the *Centre* from 180. for the *Angle* of the *Centre* and *Angle* of the *Figure* makes two *Right Angles*. The *Angle* of the *Bulwark* or *Baſtion k. a. k.* is found, if to half the *Angle* of the *Figure* you add 15 degrees, ſome add to it 20 degrees. The *Angle a. f. o.* or *k. f. o.* is found, if you deduct ½ the *Angle* of the *Bulwark* from ½ the *Angle* of the *Figure*, for becauſe *e. b.* and *a. p.* are parallel. The *Angle e. a. s.* is equal to *q. e. b.* and *a. f. o.* is equal to *k. a. s.* The *Angle o. k. f.* is had by ſubſtracting the *Angle k. f. o.* from 90 degrees, for ſince *k. o. f.* is a *Right Angle*, *o. k. f.* and *k. f. o.* muſt make another *Right Angle*. The *Angle a. t. p.* will be found, if you double the *Angle k. f. o.* which ſubſtract from 180 degrees, the Remainder is the *Angle o. t. f.* or *a. t. p.* for the *Angle k. f. o.* and *f. u. o.* are equal by conſtruction, therefore *k. f. o.* doubled is equal to them both. Now theſe *two Angles* being known in the *Triangle f. t. o.* the *third* alſo will be known, *Eucl.* 32. 1. and *o. t. f.* is equal to *a. t. p.* by *Eucl.* 15. 1. The *Angle o. k. a.* is found, if you ſubſtract *o. k. f.* from 180. for *o. k. a.* and *o. k. f.* make two *Right Angles*, Eucl. 13. 1. The *Angle a. e. o.* is found by ſubſtracting 9. *b. e.* half the *Angle* of the *Figure* found from 180. for 9. *b. e.* and *a. e. o.* are equal to two *Right Angles*, Eucl. 13. 1. as aforeſaid.

Prob.

Prob. III.

How any Regular Fortification *may be delineated Mechanically.*

This may be uſeful to them who are not skilled in *Arithmetick*, or who, in great haſte, or in caſe of neceſſity, are forced to entrench themſelves, when the Enemy and Time will not permit to make uſe of much Curioſity and Art.

Example, Fig. 2.

1. Divide the ſide of the *Polygon* given *A. B.* into five equal parts.
2. Take $\frac{1}{5}$ for the *Gorge a. c.* and *g. b.*
3. Upon *c.* and *g.* raiſe *Perpendicular Lines* of an indifferent height.
4. Give $\frac{1}{5}$ to the ſecond *Flank e. c.* and *h. g.*
5. Draw *Lines* from the *Centre k.* prolonged through *a.* and *b.*
6. Apply from *a.* to *f.* and from *b.* to *l.* $\frac{2}{5}$ of the *Line A. B.* for the *Capital Line.*
7. Draw from *f.* to *h.* and from *l.* to *e. blind Lines*, which will cut the *perpendicular Lines* from *c.* and *g.* at *d.* and *i.* and ſo you will have the *Flanks c. d.* and *g. i.* and the *Faces* of the *Bulwarks f. d.* and *l. i.* the *Scale* you may make as you pleaſe, as ſuppoſe from *a.* to *b.* were 600 or 700 Feet, more or leſs, according to which the reſt of the *Lines* have their proportion.

Prob. IV. Fig. 3.

Another way ſet down by Fritach, *to fortifie any* Regular Figure *Mechanically.*

Divide *A. B.* the *Polygon* into three equal parts, $\frac{1}{3}$ gives the Capital *A. C.* or *B. D.* again divide *A. B.* into five equal parts, $\frac{1}{5}$ whereof gives the *Gorge A. E.* or *F. B.* divide alſo *A. B.* into ſeven equal parts, $\frac{1}{7}$ part ſhall be the *Flank E. O.* and *F. H.*

CHAP. IX.

THat the Conſtitution and Ground-lines of a *Fortification* may be found, ſome things ought to be given or known; thoſe things here ſaid to be given, are thoſe *Data's* which an experienced and skilful *Engenier* knows will beſt agree with the Rules eſtabliſhed in *Chap.* VI. and from theſe *Data's* once ordered, the proportion of the reſt of the parts follow ſure and determined, according to the reaſon of the things given; therefore hath our *Author*, with much Care and Pains, made the two following *Tables*, by which are eaſily laid down any *Fortification* required. The *Proportion* of the *Lines* will ſerve for any *Form*, the *Quantity* for the *Royal* only, the *Numbers* are *Rhynland Rods*, and *Centeſimes* of a *Rod* of 12 Feet.

For

First Table for the Lines.

	Semidiameter.		Polygon Inter.		Gorge.		Capital		Flank.		Second Flank.		Courtin		Face.	
IV	42	76	60	57	12	24	15	83	7	74	08	94	36	00	24	00
V	52	34	61	54	12	77	17	33	9	09	13	10	36	00	24	00
VI	62	39	62	39	13	19	18	71	10	07	14	02	36	00	24	00
VII	72	68	63	07	13	53	20	03	10	83	13	89	36	00	24	00
VIII	83	15	63	64	13	82	21	29	11	44	13	27	36	00	24	00
IX	93	70	64	10	14	05	22	99	11	61	12	41	36	00	24	00
X	103	38	63	89	13	94	24	07	12	00	12	41	36	00	24	00
XI	114	14	64	33	14	16	24	49	12	00	14	02	36	00	24	00
XII	124	77	64	39	14	29	24	85	12	00	15	22	36	00	24	00

Second Table for the Lines.

	Semidiameter.		Polygon Inter.		Gorge.		Capital		Flank.		Second Flank.		Courtin		Face.	
IV	38	14	53	94	8	97	20	01	8	00	06	14	36	00	24	00
V	48	8	56	53	10	26	21	03	9	00	10	58	36	00	24	00
VI	59	19	58	19	11	8	22	15	10	00	11	86	36	00	24	00
VII	68	47	59	42	11	71	23	31	11	00	12	03	36	00	24	00
VIII	78	60	60	31	12	16	24	48	12	00	11	67	36	00	24	00
IX	90	31	61	77	12	89	24	64	12	00	12	95	36	00	24	00
X	101	84	62	94	13	47	24	66	12	00	13	90	36	00	24	00
XI	113	38	63	90	13	95	24	76	12	00	14	63	36	00	24	00
XII	124	77	64	59	14	29	24	85	12	00	15	22	36	00	24	00

For the Angles first Table.

	Angle of the Centre.			Angle of the Figure.			Angle of the Bulwark.			Angle C F A			Angle A C F		
IV	90			90			65			12			77		
V	72			108			72			17			73		
VI	60			120			80			20			70		
VII	51	25	43	128	34	17	84	17	03	22	8	34	67	51	26
VIII	45			135			87		30	23	45		66	15	
IX	40			140			90		00	25			65		
X	36			144			90		00	27			63		
XI	32	13	38	147	16	22	90		00	28	18	11	61	12	11
XII	30			150			90		00	30			60		

For the Angles second Table.

	Angle of the Centre.			Angle of the Figure.			Angle of the Bulwark.			Angle C F A			Angle A C F		
IV	90			90			60			15			75		00
V	72			108			69			19			70		30
VI	60			120			75			22			67		30
VII	51	25	43	128	34	17	79	17	09	24	38		65	21	26
VIII	45		00	135			82	30		26			63		45
IX	40		00	140			85			27			62		30
X	36		00	144			87			28			61		90
XI	32	43	38	147	16	22	88	38	11	29	19	05	60	40	55
XII	30			150			90			30	00	00	60	00	00

CHAP.

CHAP. X.

How to delineate any Fort *according to the* Proportions *in theſe* Tables.

1. IF you would make a *Square Figure*, a *Pentagon*, *Hexagon*, *Heptagon*, &c. and have not any *Scale* or *Sector* of equal parts, then you may make a *Scale* greater or ſmall, according as you deſign to make the *Polygon*; Divide it into ten equal parts, and every 10th part divide into ten parts, then will the whole *Scale* be divided into 100 equal parts, and by imagining each part ſubdivided into ten parts, ſo will the whole *Scale* be 1000. *Plate* 7. *Fig.* 1.

2. If you would draw a *great Royal*, according to the *Proportions* in the *firſt Table*, then take out of that *Table* the *Semidiameter* or *Radius* of that *Polygon* that you intend to draw, (for *Example*, an *Hexagon*,) which in the *Table* is 62. 39. that is, 62 *Rods*, 3 *Foot*, and 9 *Tenths* of a *Foot*, or 62 *Rods*, and 39 *Centeſmes* of a *Rod*, which take off from the *Scale*, and draw a *Circle*, as 1, 2, 3, 4, 5, 6. as in *Fig.* 2. *Plate* 9.

3. This done, take off the *Scale* the length of the *interior Polygon* 62. 39. or ſide of the *Figure*, which the *Table* ſhews that diſtance, apply it to the *Circumference* 4, 5, 6, 7. 8 or 9 times, as the *Polygon* is that you intend to draw, that is 6 times

in

in the *Hexagon*, draw the blind *Lines* from the *Centre*, and through the ſeveral *Diviſions* 1,2,3,4,5,6. and alſo *Lines* from 1 to 2, and from 2 to 3, and from 3 to 4, and from 4 to 5, and from 5 to 6.

4. Take off from the *Scale* the *Capital Line* 18. 73. as in the *Table*, and ſet it off at all the *Angles* of the Ground-plot, *viz.* from 1 to 2, and from 2 to 3, *&c.*

5. Take the length of the *Gorge* 13. 79. from the *Table* upon your *Scale*, and ſet it off from 1 to 7, and from 2. to 8. and upon the two Points 7 and 7. raiſe *upright* or *perpendicular Lines*, as 7, 8. and 7. 8.

6. Take off from the *Table* the length of the *Flank*, *viz.* 10. 07. upon your *Scale*, and ſet it off from 7 to 8.

7. Draw the *Face* from the uppermoſt part of the *Capital Line d.* to the uttermoſt part of the *Flank* 8. and ſo for the reſt of the *Lines*, they are eaſily ſet off and transferred from theſe, and ſo is your *Draught* finiſhed.

Thus may you by the *Tables*, and a *Scale* of equal parts, eaſily and readily delineate any *Regular Figure* whatſoever two ſeveral ways, according to the *firſt* or *ſecond Table*, for the *Ingenious Artiſt* may uſe which he ſhall find moſt convenient for his purpoſe, ſetting them off by his *Scale* or *Setter*, as hath been taught. And by the *Rule of Three*, theſe *Tables* may ſerve for any *Proportions* whatſoever.

But foraſmuch as theſe *Data's* may be varied without any prejudice to our *Maxims* of *Fortifica-*

tion,

tion, the *Conſtitution* of the *Ground-lines* will be various, according to the experience and opinions of ſeveral *Engeniers*, I ſhall therefore ſhew the *Conſtitution* and making the principal *Ground-lines* of any *Fortification*, according to the ſeveral ways uſed by other more famous and modern Authors, viz. *Dutch*, *Engliſh*, *Italian*, *French*, &c.

And firſt of the *Dutch* or *German* ways, who, although they have filled the World full of *Books*, and ſeveral ways of *Fortification*, yet *Maralois*, *Fritach*, *Goldman*, and *Dogen* all agree, to make the *Courtain* 36 *Perches*, or 432 *Rhinland Feet*, the *Face* 24 *Perches*, or 288 of the aforeſaid Feet, ſo that the proportion of the *Courtain* to the *Face* is as 3 to 2. the *Angle* forming the *Flank* is always 90 degrees; the *Angle* of the *Bulwark* is half the *Angle* of the *Figure* increaſed with 15 degrees; *Goldman*, *Maralois*, and *Fritach* agree in the *Angle* of the *Bulwark*, but *Dogen* makes the *Angle* of the *Bulwark* equal to $\frac{2}{3}$ of the *Angle* of the *Figure*: ſo that all their *Data's* are very near the ſame with thoſe our *Author* hath before laid down.

As to our *Engliſh* Authors, I ſhall mention only Mr. *Norwood*, who differs very little in his *Maxims* from our *Author*, for indeed the *Dutch Fortification* was then moſt uſed. And Sir *Jonas Moor*, who was indeed an able *Mathematician*, and had great experience in this Art, after he had ſhewed the ſeveral ways of all *modern Enginiers*, tells us, That 'tis moſt agreeable to practiſe the *interiour Polygon* being 1000, to take 333 Feet for the *Capital*, 200 for the *Gorge* and *Flank*, and 600 for the *Courtain*, ſo that he agrees with *Manaſſen Mallet* Author of *Travax de Mars*, And for a gene-

general Rule take, *ſaith he*, $\frac{1}{3}$ of the *interior Polygon* for the *Capital* $\frac{1}{7}$ of it for the *Gorge* and *Flank*, where there is no *ſecond Flank*, and where the *Flank* and *Capital* ſtand at *Right Angles*.

The Emperor *Ferdinand* III. ſets down (as *Schotus* that learned *Jeſuite* tells us,) an univerſal way to lay down the *Lines* of any *Fort*, *viz.* to divide the *interior Polygon* into 22 parts, of theſe take 5 for the *Gorge*, 8 for the *Capital*, and 4 for the *Flank*: Or ſuppoſing the *Polygon* to be divided into 1000, the *Capital* is 363, the *Gorge* 227, the *Flank* 181. this is a good *Proportion*, and for ſuch as are not well skilled in *Trigonometry*, may very well be uſed, Sir *Jo. Moor*.

Of the Italian *Fortifications.*

And firſt of *Signior Pietro Sardi*, who makes the *interior Polygon* 800 *Venetian Feet*, his *Gorges* and *Flanks* 150. and determines the *Face* of the *Baſtion* by the *Line* of *Defence*, razing which in a *Square* or *Pentagon* falls upon the 10th part of the *Courtain*, in an *Hexagon* on the 4th part. In an *Heptagon*, *Octagon*, *Enneagon*, on the 3d part, in all above on the half. To lay this down: Suppoſe an *Hexagon* whoſe *interior Polygon* is 1000, then 187 will be the *Proportion* for the *Gorges* and *Flanks*, which prick off from 4 to 7, and from 5 to 7, and raiſing a *Perpendicular* at 7, ſet off the ſame diſtance from 7 to 8 for the *Flanks*; then for the *Face a. d.* divide the *Courtain* 7, 7, into four parts, and ſet off $\frac{1}{4}$ from 7 to *e.* then lay a Ruler from *e.* to *b.* and draw *a.b.* for the *Face*, but if it had been *Square* or *Pentagon*, then 8 *d.* had been $\frac{1}{10}$ of the

the *Courtain*, if it had been an *Heptagon*, *Octagon*, *Enneagon*, then 8 *d.* had been $\frac{1}{3}$ of the *Courtain*, if above $\frac{1}{5}$ from the oppoſite *Flank*.

2. *Tenſini*, in ſmall Forts above the *Pentagon* makes the *Gorge* and *Flank* equal, and both a 7th part of the *interior Polygon*, and the *Face* in all *Figures* one 3d of the ſaid *Polygon*. To delineate this: Suppoſe an *Hexagon* whoſe *interior Polygon* 5, 6. is divided into 1000. the *Gorge* and *Flank* will be as in the *Table* 143. the 7th part, which ſet off from 5 to 7. and from 6 to 7. and raiſing 7, 8. at *Right Angles*, ſet the ſame diſtance from 7 to 8. then take $\frac{1}{3}$ part of *p. p.* and ſetting one foot of the *Compaſſes* in 8 croſs the *Capital Line* in *d.* and draw 8. *d.* which do to every *Baſtion*, till all be complete.

Of the French *Fortifications.*

The chief of theſe are *M. de la Mont*, and *Manaſſon Mallet*, both theſe divide the *interior Polygon* into five parts, and take one for the *Gorge*, and alſo divide the *interior Polygon* into three parts, and take one for the *Capital Line*; only *De la Mont* takes $\frac{1}{4}$ of the *Courtain* for the *Flank*, and *M. Mallet* makes the *Angle* of the *Flank* and *Courtain* to be 98 degrees, (leaving no *ſecond Flank*,) and ſo lays the *Courtain* more open for uſe, and yet not ſo much as to ſubject it to the ruine of the Beſiegers.

I muſt not forget *D. Ville*, and *Furneirs*, who divide the *interior Polygon* into ſix parts, take one for the *Demigorge* and *Flank*, being both equal, and at *Right Angles*, if the *interior Polygon* be 1000, the *Gorges* and *Flanks* will be 166.

I ſhall

I ſhall add a ſhort *Table*, by which, and the *Rules* aforeſaid, you may lay down any *Fortification* according to theſe Authors.

	Capital	*Gorge*	*Flank*	*Courtain*
Fritach.	400	220	200	560
Dogen.	351	167	200	666
Emperor.	363	227	181	546
P. Sardi.		187	187	626
Tenſini.		143	143	714
G. Maria.		125	138	750
De la Mont.	333	200	150	600
Maneſſon.	333	200	200	600
Fren. Conqueſt.		200	240	600
Furneir, &c.	228	166	166	666

In this *Table* you have the *Proportions* for the *Capital*, *Gorge*, *Flank*, and *Courtain*, ſuppoſing the length of the *interior Polygon* 1000 *Engliſh* Feet, according to theſe ſeveral Authors. But if the *interior Polygon* be leſs than a 1000, the *Proportions* in this and in the former *Tables* may be reduced to any other *Polygon* required, by multiplying the *length* given by any of thoſe *Numbers*, and cutting off the three laſt places. *Example.* A *Polygon* given is 750, what ſhall be the *length* of the *Capital*, *Gorge*, *Flank*, and *Courtain*, according to any of the aforeſaid Authors. For *Example*, to *De la Mont.* multiply 750 by 333, gives 249 Feet for the *Capital*, ſo for the *Gorge* multiply 750 by 200, and there is 150 for the *Gorge*, then multiply 750 by 150, and there will be 112 for the *Flank*, and after the ſame manner 450 for the

Cour-

Courtain. And thus you may proportion any of theſe Authors to any *interior Polygon*, which muſt not exceed 800, nor be leſs than 500, for if leſs, your *Fort* will be fit only for *Cittadels* or *Field-works*, but if more than 800 Foot, too big for a *Fort-Royal*, and muſt be well ſtored with *great Guns.*

I ſhall only mention Count *Pagan*'s way which was at one time much approved of here in *England*; he was indeed a great *Mathematician*, and much experienced in many *Campagnes* and *Sieges*, he works by the *exterior Polygon*, and his chief *Proportions* are in the *Table* following.

Exterior Polygon.	1200	1080	1000	960	820	720	600
The half.	600	540	500	480	410	360	300
Length of the Courtain.	425	364	334	304	275	234	164
	212 1/2	182	167	152	137 1/2	117	82
Length of the Perpendicular.	180	180	180	180	150	144	138
Length of the Face.	364	336	308	288	242	222	200
Complem. of the Line of Defence.	222	192		162	162	162	90

To draw a *Fort* after this way, draw the *exterior Polygon C. D.* divide it into two equal parts at *E.* which ſuppoſe 600 each, and raiſe the *Perpendicular E. L.* upon which ſet off the length of the *Perpendicular* in the *Table*, *viz.* 180. which will terminate in the *Point F.* then from either *Point D.* and *C.* draw *Lines* to *F.* viz. *C. F.* and *D. F.* then ſee in the *Table* for the length of the *Face*, *viz.* 364. which ſet off from *C.* to *I.* and from *D.* to *K.* then (meaſure out the length of the half *Courtain*, *viz.* 212 1/2 from *L.* to *H.* and *G.* or elſe) take out the Compl. of the *Line* of *Defence*,

viz. 217. and ſet it off from *F.* to *H.* and fro
F. to *I.* then from *H.* and *I.* and from *G. K.* dra
the *Flank.* Thus obſerving the ſame method fro
each *Baſe* or *exterior Polygon*, you may delinea
any *Fortification*; but to fortifie a *Square*, the *Pr*
portions are to be altered thus:

Baſe or exterior Polygon—	600	550	640	52
Perpendicular ————	161	146	173	13
Face ————	364	326	384	29
Compl. ————	222	211⅓	243⅓	21

And may be delineated by the foregoing *Di*
rections.

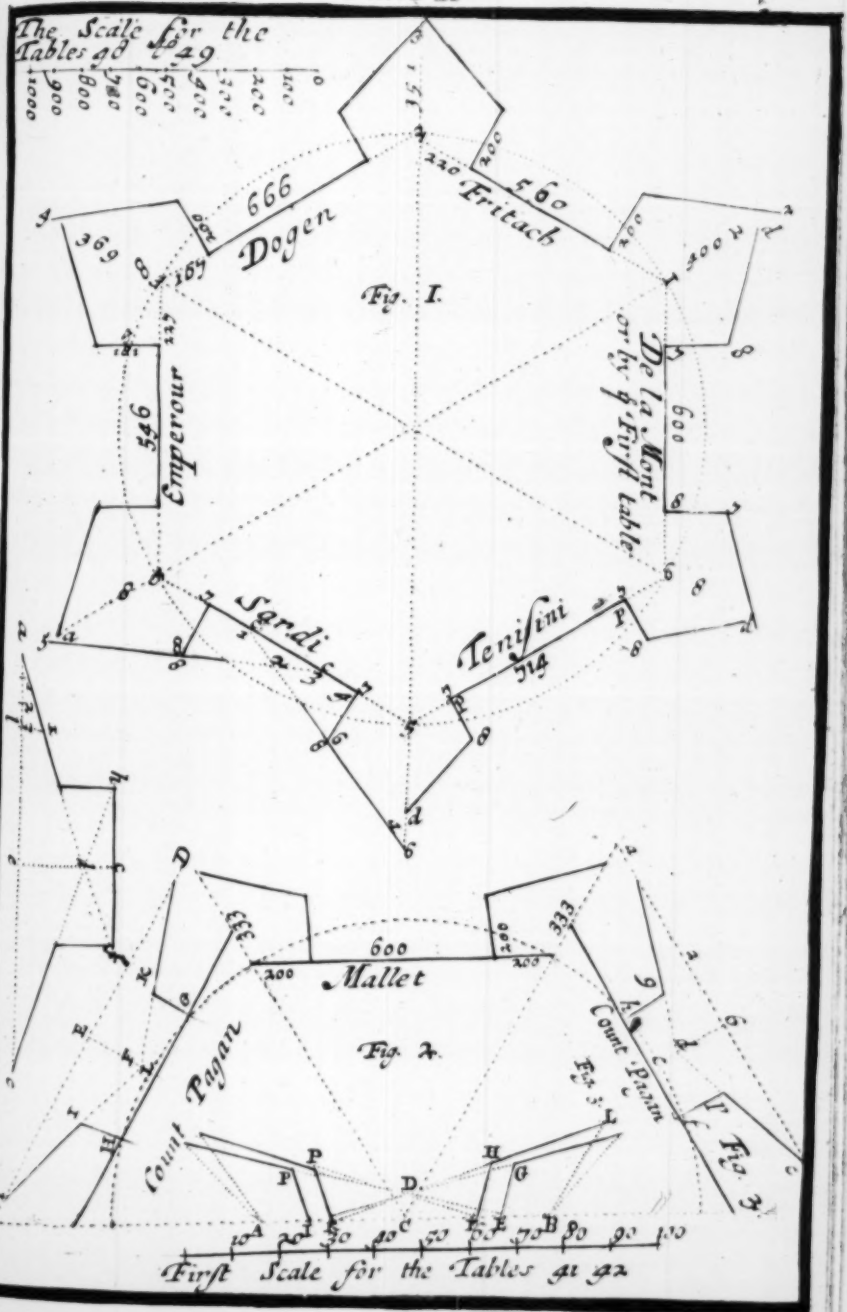
Thus have I ſet down the ſeveral ways for lay
ing down the *fundamental Ground-line* from th
moſt conſiderable *Engeniers* of this Age, which wi
better appear by *Plate* 9.

How mechanically to delineate or draw out in the Fie
any Fortification Regular *or* Irregular, *eith*
from the exterior *or* interior Polygon, *accordin*
to Count Pagan's *method.*

And firſt from a Pentagon *to a* ſtrait Line *from th*
exterior Polygon.

Divide the given *Baſe* or *exterior Polygon a.*
as in *Plate* 9. into two equal parts in the *Point*
from the *Point b.* erect the *Perpendicular e. b.* of
ſufficient length, then divide *a. b.* the half *Baſe* in
to 3, 6, or 9 equal parts, and take ⅓ thereof fo
the *Perpendicular b. d.* ſo is *d.* a *Point*, through whic
dra

Plate IX


The Scale for the Tables 48 & 49
Dogen
Fritach
Fig. I.
Emperour
De la Mont or by ye First table
Sardi
Tenisini
Mallet
Fig. 2.
Count Pagan
Fig. 3.
First Scale for the Tables 41 42

draw the *Line a. d.* and *d. c.* which done, divide the *Perpendicular b. d.* into 8 equal parts, and make *d. h.* and *d. f.* equal to 9. of thoſe parts, then from the *Points h.* and *f.* let fall the *Perpendiculars h. g.* and *f. p.* till they cut the *Lines a. f.* and *c. h.* in the *Points g.* and *p.* then join the *Points a. g. h.* and *f. p. c.* and ſo have you *a. g.* and *c. p.* for the two *Faces g. h.* and *f. p.* for the two *Flanks*, and *h. f.* for the *Courtain* of the *Fortification*, Plate 9. *Fig.* 3.

From a Square, *to a* Pentagon.

The method of drawing this is the very ſame with the former, only inſtead of dividing the half *Baſe a. c.* into 3, 6, or 9 equal parts, and taking the $\frac{1}{3}$ thereof for the *Perpendicular*, you muſt here divide the half *Baſe a. c.* into 15 or 30 *lengths*, and ſet off 4 or 8 for the *Perpendicular d. b.* and inſtead of dividing the *Perpendicular d. b.* into 8 parts, you are to divide it into 5, and of theſe parts you are to ſet off 7 upon both the *Lines d. f.* and *d. h.* and this is all the difference.

Or note, that having erected your *Perpendicular*, then take any meaſure whatſoever, be it *Pole*, *Staff*, *Line* or *Stake*, and mark out 3, 6, 9, 12, 15, 18, 21, *&c.* upon the *Line a. c.* to the *Point l.* upon which *Point* raiſe a *Perpendicular l. k.* equal to $\frac{1}{3}$ of *a. l.* ſo is *k.* a viſual *Point*, through which is to be drawn the *Line a. f.* cutting the *Perpendicular c. e.* in the *Point d.* and *e.* a viſual *Point*, through which is to be drawn the *Line c. h.* then proceed as be-

fore directed for the *Pentagon:* But for the *Square*, inſtead of marking out 3 *lengths* upon the half *Baſe*, you are here to mark out 15 for the *Line a. l.* and inſtead of $\frac{1}{3}$ you muſt allow 4 of thoſe parts for the *Perpendicular k. l.*

To perform this by the *interior Polygon*, and that from the *Square* and *Pentagon* to a *Right Line*, let the *interior Polygon* given be *A. B.* which divide into 12 parts, then make *d. e.* $\frac{1}{15}$ and *a. i.* $\frac{2}{15}$ for a *Square*, and *a. k.* $\frac{3}{15}$ for a *Pentagon*, *p. k. l.* and *p. i. g. right Angles*, and proceed as before directed, *Plate* IX. *Fig.* 4.

Here note alſo, that the *exterior Polygons* ought to be about 1150 *Feet*, and never leſs than 1024, nor yet more than 1280, that ſo the *Line* of *Defence* may not be too ſhort, or exceed the Port of a *Muſquet-ſhot*, and that the *Angle* of the *Baſtion* be in no caſe whatſoever leſs than 60 degrees; But where either the *Scituation* of a place, or the old *Walls* or *Rampires* of a Town will not admit any ſuch equality either of *Baſes* or *Angles*, then the *Engenier* may either open or ſharpen his *Angles*, or lengthen or ſhorten his *Lines*, as he ſhall find it neceſſary.

Of the Explanation of the Orthographical *Terms.*

Hitherto I have delivered the *Delineations* of *Regular Fortification*, according to the *Ichnographical* part of it, Now I come to the *Orthography*, in which all parts of *Fortification* as to their *Heights* and *Thickneſs*

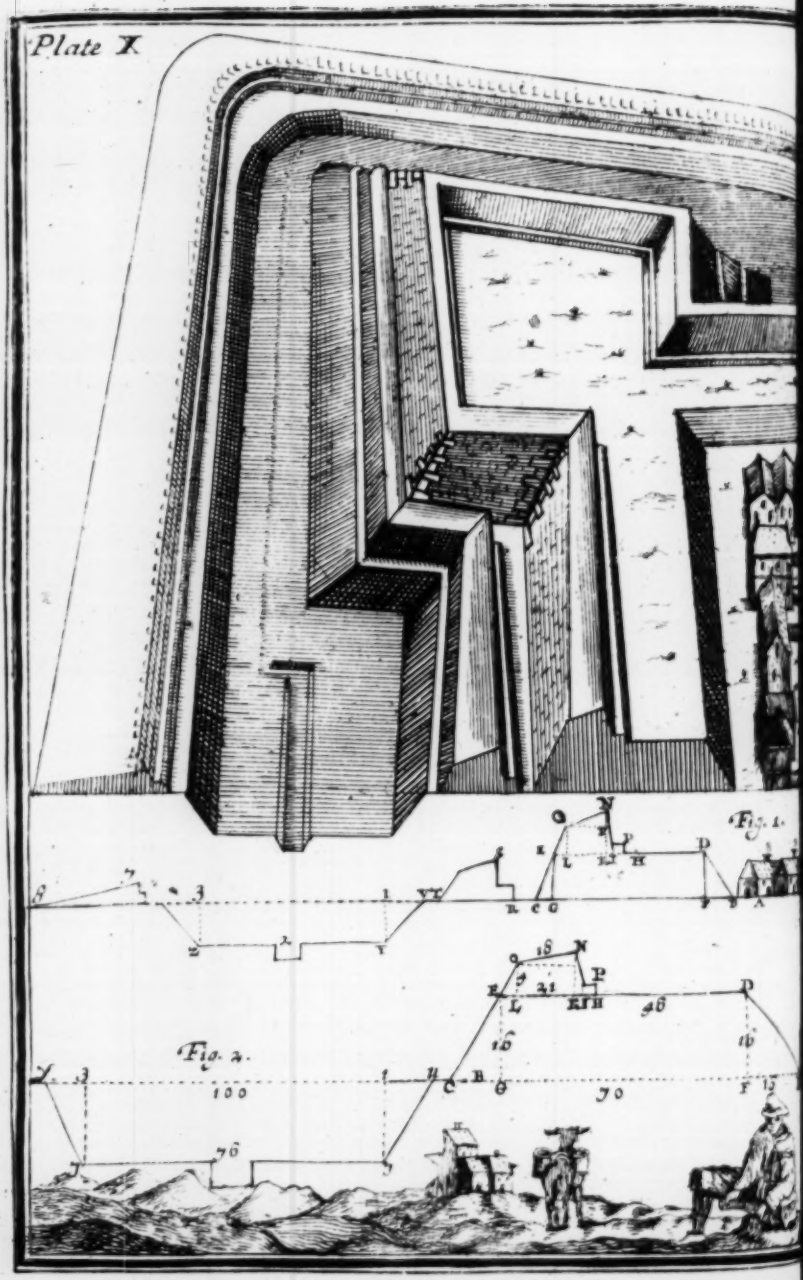
Thickneſs are contained, and firſt of the *Explanation* of *Terms*, as in *Fig.* X. according to the

	Latin.	French.	Engliſh.
B C	*Planta, pes, latitudo Valli Horizontalis.*	*Pied ou le Baſe du Rampart, la Baſſa ou le piedRampart.*	*The Foot or Baſe of the Rampire, the Horizontal, or Ground-line.*
D F	*Altitudo Valli.*	*Haulteur du Rampart, ou la Largeur du Rampart par, le, haut.*	*The Height of the Rampire.*
B C	*Acclivitas Valli interior.*	*Le penchant, la Montee, interieur duRampar.*	*The inward ſloop of the Rampire.*
C E	*Acclivitas Valli exterior.*	*La penchant la Montee exterieur.*	*The Outward ſloop of the Rampire.*
B F	*Eriſma Valli interius.*	*La Talus interieur.*	*The inward Tale.*
G C	*Eriſma Valli exterius.*	*La Talus exterieur.*	*The outward Talu.*
D E	*Latitudo Valli Verticalis.*	*Le Sommet du Rampar, ſon eſpeſſeur au haut.*	*The upper thickneſs of the Rampire.*
D P	*Statio ſive ambulacrum Vallare.*	*La Haute allee ou Terraplein.*	*The Walk or Terraplaine.*
I N O E	*Lorica.*	*Le Parapet.*	*A Breaſt-work.*
I E	*Pes Thoracis, latitudo Loricæ Horizontalis.*	*Baſſe du Parapet, ou le pied.*	*The Baſe of the Parapet, or Breaſt-work.*
O E	*Acclivitas Loricæ exterior.*	*Le penchant exterieur du Parapet.*	*The outward ſloop of the Parapet.*
N I	*Acclivitas Loricæ interior.*	*Le penchant interieur.*	*The inward ſloop of theParapet.*
E L	*Eriſma Loricæ exterior.*	*Le Talu exteieur du Parapet.*	*The outward Tale.*
I K	*Eriſma Loricæ interior.*	*Le Talu interieure.*	*The inward Tale.*

	Latin.	French.	English.
N O	*Latitudo Verticalis Loricæ.*	*Sommet du Parapet ; Son eſpeſſeur en haut.*	*The Breadth at the Top.*
P H I	*Scabellum, ſuppedaneum.*	*La Banquette.*	*A Foot Bank.*
C R	*Statio, ſive ambulacrum promurale.*	*Chemin des Rondes, la Baſſe allee, ou Fauſſebraye.*	*The Plane or Walk of the Fauſſebraye.*
R S T	*Promuralis.*	*La Fauſſebraye.*	*A Fauſſebraye, a Counter-wall, or Breaſtwork.*
T V	*Margo promuralis.*	*La Liſiere, relief, ou Berne.*	*The Foreland or Bankſide of the Ditch, the Barm, or Lizier.*
V Y Z X	*Foſſa.*	*Le Foſſe.*	*The Moat or Ditch.*
I Y	*Foſſæ profunditas.*	*Profundeur du Foſſa.*	*The depth of the Ditch.*
V Y	*Declivitas Foſſæ interior.*	*L'Eſcarpe.*	*The inward ſloap of the Ditch.*
Z X	*Declivitas Foſſæ exterior.*	*Contre-eſcarpe.*	*The outward ſloap of the Ditch.*
V I	*Eriſma Foſſæ interior.*	*Le Talus de l'Eſcarpe.*	*The inward Talu of the Moat.*
X 3	*Eriſma Foſſæ exterior.*	*Le Talus de la Contre-eſcarpe.*	*The outward Talu of the Moat.*
X 4	*Statio Suburbana via Coperta.*	*Le Chemin Covert, Corridor.*	*The Covert way.*
4 5 7 8 6	*Scabellum, & Lorica Viæ tectæ.*	*The Banquet, & Parapet du Chemin Covert, l'Eſplanade.*	*The Foot-Bank and Breaſt-work of the Covert way.*
8 6	*Baſis. pes Loricæ extimæ, planta Campeſtris Thoracis.*	*Pied, ou Baſe du Parapet de Chemin Couvert.*	*The Baſis or Ground-line of the Chemin Covert.*
7 8	*Declivitas Loricæ Suburbanæ.*	*Eſt l'Eſplanade, ou vray glacis.*	*Outward ſloaping of the Breaſt-work of the Covert-way.*

Of

Plate X.



Of the Orthographical *Dimenſions and Meaſures of the* Profiles *of* Fortifications.

Of the Rampire. *Plate* X.

Every *Fortification* conſiſts of theſe four Parts:

1. The *Rampire*, with its *Parapets* or *Breaſt-works.*
2. The *Fauſſebray*, or *Counter-breaſt-work.*
3. The *Ditch* or *Moat.*
4. The *Breaſt-work* of the *Covert way*, by the French, *le Glacis.*

The *Rampire* is generally made of *Earth* taken out of the *Ditch* or *Moat*, and heaped up to ſuch a *thickneſs*, that it may be *Cannon-proof.* The *thickneſs* and *height* of the *Rampire* is various, therefore to give *Rules* for the *thickneſs* of the *Works* according to the *nature* of the *Polygon*, is needleſs. The *height D. F.* may not exceed 18 Feet, nor be leſs than 10, but in caſe of *Hills* near the *Fort*, you muſt raiſe *Cavaliers* in your *Bulwarks.*

The *lower thickneſs* of the *Rampire B. C.* may be from 80 to 50 Feet, for all *Royal Forts* generally 70, but indeed according as *Earth* is to be had, therefore we cannot be poſitive in its *Dimenſions.* The *Rampire* muſt be ſo built, that both *without* and *within* it may be *ſloaping*, foraſmuch as a *Rampire* made of *Earth* cannot be built *upright.* The *Sloap* of the inward ſide of the *Rampire B.D.* is commonly a Foot for a Foot, that is, if the *Height D. F.* be 18, the *Talu G. F.* will be 18. if 15, then 15, *&c.* The *outward Sloap C. E.* is generally in proportion half a Foot, for a Foot,

that is, if the *Height G. E.* be 18 or 15, then the *Talu G. C.* will be 9 and $7\frac{1}{2}$, but ſome *Earth* will ſtand better than other, and may ſomtimes require to be lined with *Bruſhwood* and *Fagots*, *Experience* muſt be the Guide.

The *upper thickneſs* of the *Rampire D. E.* is found, if from the *lower* you ſubſtract the *outward* and *inward Talu*, upon which there is always a *Breaſt-work* or *Parapet* built, *viz. i. n. o. e.* whoſe *Dimenſions* are:

1. Its *inward Height*, that is, *I. N.* muſt be 6 Foot, that it may conveniently ſhelter the *Soldiers*.

2. The *outward Height O. L.* muſt be 4 Foot, to give a *Sloap* to defend the *Counterſcarp*, *Ditch*, and the *Field*.

3. The *inward Talu I. K.* will never need to be but 1 Foot, the *outward Talu L. E.* may be always 2 Foot.

4. The *upper thickneſs* of the *Parapet* muſt be *Cannon-proof*, and therefore *alterable*, according to the Nature of the *Soil*, in *light Earth* 20, in *ſtiffer* 16, and in *ſolid rough Clay* 14 Feet.

5. The *lower thickneſs I. E.* is compoſed of the two *Talus's I. K. L. E.* and the *upper thickneſs N. O.*

6. The *Footſtep* or *Banquet*, which is built at the foot of all *Breaſt-works*, on the *inſide* is about 3 feet thick or broad, and $7\frac{1}{2}$ high.

7. The *Terraplain* or Walk upon the *Rampire D. P.* is found, if from the *upper thickneſs* of the *Rampire D. E.* you ſubſtract the *lower thickneſs* of the *Breaſt-work I. E.* and the *thickneſs* or *breadth* of the *Step H. I.* there remains *D. P.* for the *Terraplain*.

If

If the *Rampire* wants a *Fauſſebray*, a *Parapet des Rondes*, or *Counter Breaſt-work*, for the defence of the *Moat* or *Wet-ditch*; then there is often left a *Bankſide*, or a *Space of Earth* about 6 Foot broad from the Foot of the *Rampire* to the Brink of the *Ditch*, as *T. V.* which is called the *Foreland Barm* or *Lizier*. Our late *Engeniers* leave out this *Foreland*, and make a Wall of *Stone* or *Brick* from the bottom of the *Moat* to the *Rampire*; or in caſe of neceſſity to make it, the *leſs* the *better*, only enough to ſupport the *Rampire* from ſlipping into the *Ditch*.

Of the Fauſſebray.

The onely end of this *Fauſſebray*, is the defence of the *Moat*, which help a *dry Ditch* doth not ſtand in need of; ſo that thereby a great deal of *Labour* and *Mony* is ſpared, and the making of them being found *inconvenient*, are now altogether left off, and therefore I ſhall only tell you, 'tis repreſented by *R. S. T.* built at the Foot of the *Rampire*, its *height*, and the reſt of its parts are the ſame in all reſpects as that of the *Breaſt-work* of the *Rampire* aforeſaid.

If a *Fauſſebray* be made, then betwixt the *Rampire* and the *Fauſſebray* is left a ſpace *c. v.* fit for the *Beſiegers* to plant and traverſe their *great Guns*, called, *The Walk of the Fauſſebray*, whoſe greateſt *Breadth* is about 24 *Feet*, the leaſt about 12.

Of

Of the Moat *or* Ditch.

The great *Moat* or *Ditch* which ſurrounds the *Fort*, whether *dry* or *wet*, muſt be made *wider* than the *longeſt Trees*, that the *Enemy* may not lay *Bridges* over it, *viz.* from 70 to 100, 130, 140 Feet; and it may be 8, 10 or 12 Foot deep: If it be a dry *Moat*, or not very full with water, then in the middle of the bottom of the *Moat* there is made a *little Ditch* as *large* and as *deep* as the *Work* and *Earth* will give leave; but becauſe the *Earth* that comes out of this *Moat* muſt not much exceed the *ſolidity* of the *Earth* that muſt make up the *Rampire*, *Parapet*, *Fauſſebray*, *Covert way*, and other Works; the true *wideneſs* and *depth* of the *Moat* will then be beſt known, when you have found out the *Solidity* of thoſe, which ſhall be ſhewed in the following *Chapter*, for that ought to be equal to the *aggregate* of the *Works*. The *Covert way* or *Paſſage* between the *outward Sloap* or *Counterſcarp* of the *Moat* and the *Bulwark*, is left about 18 Foot wide more or leſs, as *B.C.* upon which is to be a *Breaſt-work* or *Parapet* of the ſame height, and with the ſame *Foot-bank* that the *Rampire* had on the *inſide*, only this muſt ſo ſloap into the *Campagne*, ſo that a *ſtrait Line* drawn from the top of the *Rampire N.* may terminate the *Sloap* 6, 7, 8.

Prob. I.

To find the Superficial Content *of the* Rampire *and* Parapet, *in the Orthographical* Section *or* Profile, *as alſo of the* Ditch *and* Covert Way.

To find the Superficial *Content* of the *Rampire*,

pire B D E G according to *Bocklern, Fig.* 2. *Num.* 1. Firſt, add the lower Breadth C. B. 70. to D. E. 46. the upper breadth which makes 116. The half of which is 58. which multiplyed by 16. the depth D. F. gives 928 ſquare Feet, the *Content* of the *Rampire*: Or, foraſmuch as the Earth or ſolidity that lies between theſe two G E. and D. F. is a *Parallepipidon*, all of one heighth and thickneſs the *Content* is gotten by multiplying the length G. E. or E. D. by 46. by the heigth of the *Rampire* E. G. or D. F. 16, which makes 736 for the ſuperficial *Content* of E. G. D. F. The Earth that lies on either ſide of this Body, and hath each *Talu* for its baſe, and ends at the top of the *Rampire* in a line, *viz.* B. D. F. and G. E. C. are *Priſmees* or half of *Parallepipidons*, and the ſuperficial *Content* is gotten by multiplying the Superficies at the bottom by half the heigth of the *Rampire*.

The ſuperficial *Content* of the *Parapet* I. N. O. E. is found, as the *Rampire*; for if you take the two lengths I. L. 21. and N O. 18, and add them together they make 39, the half of which is 18 ½ or 6 Inches, which multiply by 5 (for the inward height and outward height together is 10, therefore take the mean which is 5) it makes 95, and 5 times 6 is 30 for the Inches, which makes 2 Foot 6 Inches more. In all 97 ½ for the ſuperficial *Content* of the *Parapet*.

To find the ſuperficial Content *of the* Banquet *or* Foot-ſtep, *whoſe breadth is* 3. *and the height* ½, *multiply the breadth by the height* 1 ½ *it makes* 4 ½, *which added to* 97 ½ *makes* 102 *for the whole* Area *of the* Parapet.

To find the ſuperficial Content *of the* Ditch *or* Moat V. Y. X, Z.

You muſt proceed in all reſpects as with the *Rampire*, it being no more than a ſolid reverſed: That is, add the two ſides V. X. 100, and Z. Y. 76 together, which is 176, then take the half 88, which multiply by the depth of the Ditch 3 Z. or 1 Y. which ſuppoſe 12 Foot. The Product 1056 is the *Superficial Content* of the *Ditch* required.

To find the Content *of the* Breaſt-work *beyond the Covert Way* viz. 4. 5. 7. 8. 6.

This Breaſt-work or *Parapet* is always 6 Foot high, and hath about 60 Foot *Talu* to ſloap into the Campagne marked with 6. 7. 8. whoſe length 6. 8. ſhall be 61.-the heighth 6. the half 3. the whole *Area* 185.

How

How to find the ſolidity of the Rampire, *and its* Parapet, *with the* Parapet *of the* Covert Way *beyond the* Counterſcarpe, *and thereby to proportion the wideneſs and depth of the* Ditch *or* Moat.

The *Mechanical Rule* generally uſed by Workmen is this: *Take the length of both ſides, and add them together, then take half as a mean, which multiply by the Superficial Content of the Profile, the Product gives the Solidity*, practiſe in *Plate XI.* I meaſure the length of the outſide of the *Rampire* for this 12th part, *viz.* half the *Courtain*, the whole *Flank* and *Face*, which make 634 $\frac{1}{2}$ Feet, the length of the inſide of the *Rampire* ſuppoſe is 596 $\frac{1}{2}$ both added together, makes 1231. the half of which is 615 $\frac{1}{2}$. Then, as by *Page* 59, I found 928 for the *Superficial Content* of the *Profile*, now multiply the length 615 $\frac{1}{2}$ by 928, the *Product* will be 571154 ſolid Feet for the *Content* of one 12th part.

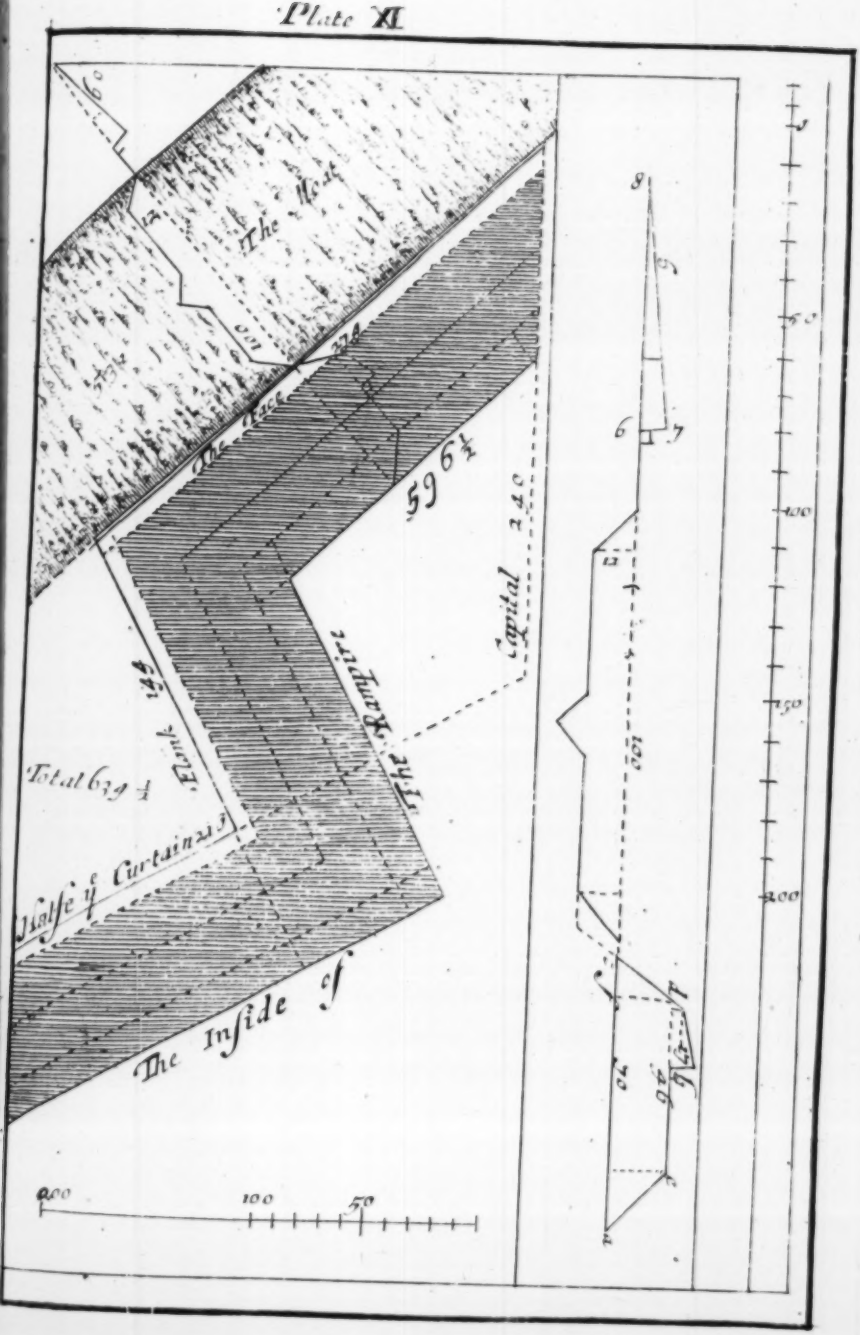
Then I meaſure the middle length of the *Parapet*, as I did the outſide of the *Rampire*, which I find to be 628 for $\frac{1}{12}$ of the *Parapet*; and for the *Superficies* of the *Profile*, as by *Prob.* 1. *p.* 59, I found to be 102, which multiplied by the length 628, gives for the *Product* 64046 ſolid Feet.

Then for the *Breaſt-work* beyond the *Covert-way*, by the laſt *Problem* the *Area* was found to be 181 $\frac{1}{2}$ and the length of this *Line* for (by taking the middle of the *Superficies* of the Triangle 7. 8. 6.) becauſe to meaſure the middle length by the former way it would be too long) $\frac{1}{12}$ part of the *Breaſt-work* will be found to be 605 $\frac{1}{4}$, which multiplied by 185, the *Area* of the *Profile* makes 111911 ſolid Feet, now adding the *Solidity* of the *Rampire*, and theſe two *Parapets* together.

The Sum of all is 647111 Solid Feet, being the $\frac{1}{12}$ of the whole.

Now

Plate XI


The Moat
The Face
Capital 240
The Rampire
Flank 144
Total 639 ½
Curtain 213
The Inside of
200
100
50
8
6
7
12
100
70
46
50
100
150
200

Now to proportion the depth of the *Moat* to this *Solidity*, firſt meaſure the length of the middle of the *Moat*, from the middle of the *Courtain* to the *Capital Line*, which you will find by the *Scale* 531, with which divide the *Solidity* 647211 of the *Rampire*, &c. the *Quotient* will be 1218 *ſuperficial Feet* for the *Profile* of the *Moat*, divide 1218 by 100 the upper length of the *Moat*, the *Quotient* is 12 Foot, and more for the depth. Now to know if this will be large enough, you muſt conſider if the Sloap be one Foot in a Foot, then at 12 Foot deep, the top being 100, the bottom of the *Ditch* is 76, the middle 88, which multiplied by 12, the depth maketh 1056, the *Superficial Content*, which multiplied by the length of the middle of the *Moat* 531, gives 560736 which is ſhort of the *Solidity* it ſhould be, therefore widen the *Moat* 10 or 12 Foot more, and make it 112 Foot at the top, and then it gives the *Solidity* required at 12 Foot deep; but if the *Ground* will not ſuffer to go ſo deep, then you muſt widen the *Moat*, ſo that you may get the aforeſaid *Solidity* Here note, that *Ingeniers* allow a 20th part of *Earth* more than the whole *Solidity*: For to want *Earth* the Remedy is very bad, and the *Charge* double; but if there be too much, 'tis no inconvenience, the 20th part of 647211 is 32360, which makes the $\frac{1}{11}$ of the *Rampire* by 679466. And thus much ought you to have for the aforeſaid *Solidity*, for you will have occaſion for *Batteries*, *Cavaliers*, *Platforms*, and other Works within the *Fort*.

This Eſtimate being only in ſolid *Feet*, will want a *Reduction* to an *higher Denomination*.

Note therefore, that a Body of *Earth* or *Stone*

here in *England* 18 Feet each way at *Right Angles*, (that is *Square*) and one Foot deep, is termed a *Floor*, ſo that all our Eſtimates for *Banks* or *Drains* are reckoned by the *Floor*, that is 324 ſolid Feet of *Earth* is a *Floor*, for if you multiply 18 by 18, the *Product* is 324.

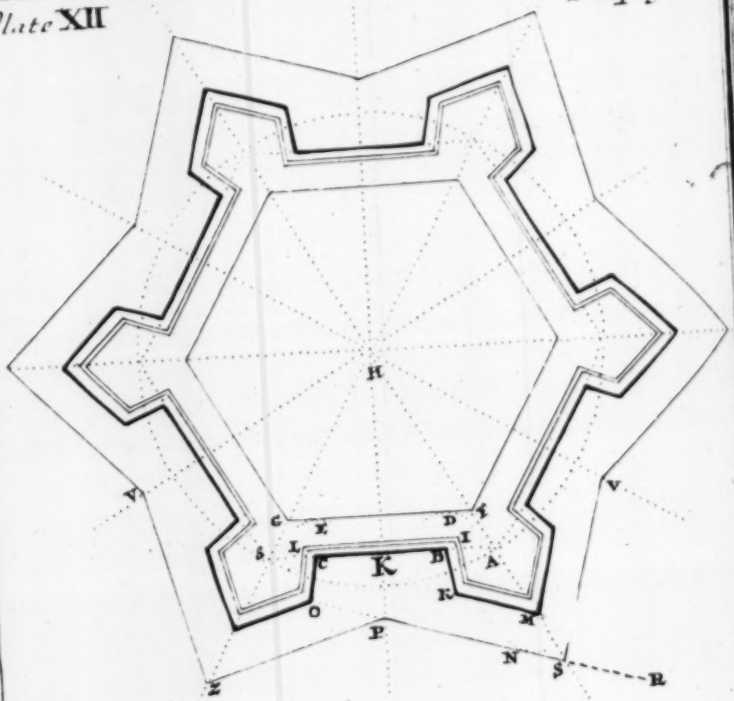
If therefore you would know how many *Floors* of *Earth* there are in this, or any other *Work*, divide the former *Solidity* 647111 Feet, by 324, the *Quotient* will be 1997 *Floors* of *Earth* $\frac{1}{4}$ and two Feet; for if the Remainder be 243, it is $\frac{3}{4}$. if 162, it is $\frac{1}{2}$ if $81\frac{1}{2}$ of a *Floor*; and becauſe this is but $\frac{1}{12}$ part of the *Fort*, there would be in the whole 23967 *Floors*, and 24 *Feet*.

There is a *Geometrical* way to find the *Solidity*, which is difficult and tedious, and not much uſed in practice; but ſuch as have a mind to peruſe ſuch large ways, may find them in *Maralois*, *Pitiſcus*, *Dogen*, *Cellarius*, and others.

Some alſo make large *Diſcourſes* about *Directions*, how to build up any *Fort* which any *Workman* or *Maſon* that undertakes the building of *Walls* needs no ſuch helps, beſides the *Circumſtances* are ſo various, the *Prices* ſo uncertain, that no *general Rules* can be given, but the *Ingenier* muſt be ruled by the *Cuſtom of the Country*, which he ought well to underſtand; And 'tis not enough for an *Ingenier* to be expert in the *deſigning part*, and in drawing *Draughts*, for one may lay down more *Forts* in an *Hour*, than all the *Princes in Europe* will build in *Ten Year*: But he muſt alſo know what belongs to the *Mechanical part*, viz. the *Maſons*, *Carpenters*, *Joiners*, *Plumbers Work*; He ought to know the prices of *Timber*, *Lime*, *Stones*, *Sand*, *Brick*, and

all

Plate XII



all other *Materials*, that he may complete the Eſtimate of his *Fort*, ſo that he may not be *overſeen*, or *promiſe* or *undertake* what he cannot *perform*, to the damage of his *Prince*, and his own *diſgrace*.

How to order the inner parts *of a* Fortification, *which are the* Streets, Gates, Bridges, *and other* accidental Buildings. *See* Plate *VI.*

1. When a Place, whether *Regular* or *Irregular*, is fixed to be fortified, and accordingly delineated in the *Field*, it is neceſſary that an exact diſtribution and ordering may be made of the *Streets*, *Houſes*, *Gardens*, and *void Places*, where obſerve, that in every *Regular Figure* all the *principal Streets* ſhall be built 20,24,or 30 Foot broad, towards the middle of the *Bulwark* and *Courtain* parallel from the *Centre*,or principal place of the *Fort*.

2. The chiefeſt *Market-place*, which will alſo ſerve for the *Rendezvous-place*, ſhall ſo be ordered in the middle of the *Town* or *City*, that it have the *Figure* of the *Fortification*, and be *parallel* to its *Sides*, that all its *Angles* may anſwer to the *Angles* of the *Bulwarks*. The *Sides* of the *Market-place* are commonly from 9, 10, to 15 *Rods*.

3. The chief Buildings of a *Fortified Place* are the *Churches*, *Market-houſes*, *Armories*, *Magazines*, or *Store-houſes*, a *Work-houſe*, *Corp de Guarde*, *Hoſpital*, *Houſes* for *Soldiers* and *Sentinels*.

4. The *Church* is commonly built not far from the *Market-place*, near it are the *Houſes* for the *Miniſters* and the *Schools*.

5. The *Senate-houſe* ſhall not be far from the *Church*, that its forepart may look towards the *Market-place* ſeparated from all other *Houſes*. There

may likewiſe be built an *Houſe* or *Palace* where the *Prince* or *Governor* of the place may abide in, if there be no *Cittadel*.

6. The *Armories* ſhall be built in the *Streets* near to the *Wall*, that *Arms* and *Guns* may be had ſpeedily; likewiſe the *Houſes* where all ſorts of *Ammunition* are kept, as *Gunpowder*, *Matches*, *Granadoes*, and other *Fireworks* be next to the *Wall*, *ſtrong arched*, *inwardly planted*, and *well ſecured* againſt *Fire* and *Water*.

7. The *Workhouſes* ſhall be near the *Armories*.

8. The *Magazines* ſhall be built on ſeveral *airy* or *lofty parts* of the *Town*, well ſecured againſt all ſorts of damage.

9. The *Corp de Garde* ſhall be upon the *Market-place*, and other ſmall *Guard-houſes* for *Officers* and *Soldiers* ſhall be near the *Gates* or *Bridges*, and may be *broad* from 46 to 64 Feet, 25 Feet *high* from the *Ground* to the *Roof*, provided with a *Chimney*, *Door* and *Windows*, and *large Banks* to lie upon, with other conveniencies belonging to it, are to be placed on the *Baſtions Angle*, and middle of the *Courtain*.

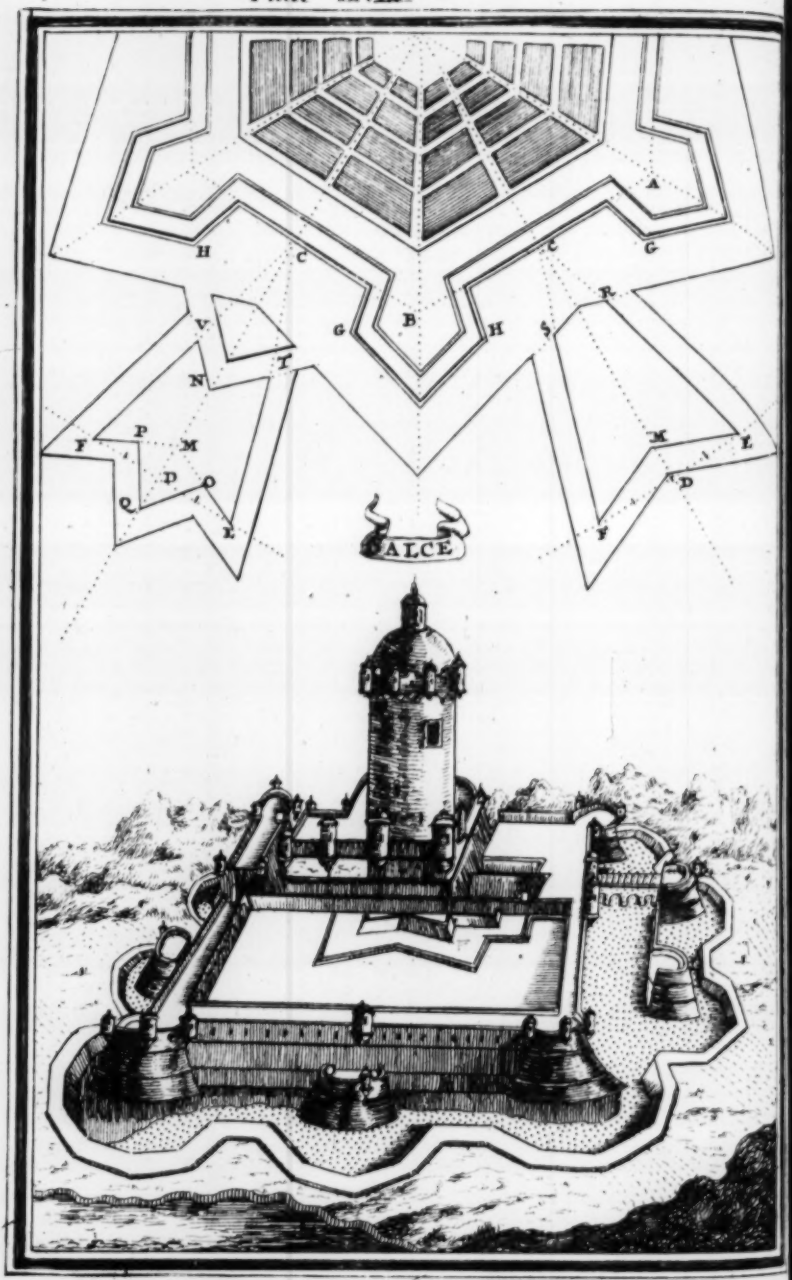
10. The *Watch* or *Sentinels Houſes* ſhall be *round*, or of a *Figure* of 6 or 8 *Angles*, with 3 *Lights* or *Day-holes*, its *height* is commonly 8 Feet, and its *width* 5 or 6 Feet.

11. The *Officers* or *Soldiers* Houſes ſhall be built near the *Wall*.

12. It is likewiſe neceſſary to have *Mills*, and where the *ſituation* will not permit *Water-Mills*, *Wind* or *Horſe-Mills* muſt be built, or they muſt be provided with a good quantity of *Hand-Mills*.

13. The

Plate XVIII.



13. The *common Houſes* for Inhabitants ought to be built of *Brick* or *Stone*, and are commonly 20 or 30 Foot *broad*, 30, 40, 50 Foot *long*.

14. The *Fountains* ſhall be (if it is poſſible) in the *Market-place* and in the *Streets*.

15. The *Ports* or *Gates* are moſt conveniently put in the middle of the *Courtain*, they are of two ſorts: Firſt, *Capital Ports*, which are commonly 10 or 12 Foot *broad*, and 14 or 15 Foot *high*, and are made according to the *thickneſs* and *proportion* of the *Wall*. Secondly, *Little Ports* are made in the middle of the *Courtains*, where they will not place *Capital Ports*, through which they may come to the *Fauſſebray* or *Outworks*, and are therefore called *Sally-Ports*, they are 6 or 7 Foot *broad*, and 7 or 8 Foot *high*, fenced with *double Gates*.

16. The *Bridges* do obſerve the *height* and *breadth* of the *Ports*, they are commonly at a *Capital Port* 12, 14, or 15 Foot *broad*, their *length* is the ſame with the *breadth* of the *Ditch*, they ought to be built of Frames of *Timber*, laid over with ſtrong *Baulkes*, that they may be *thrown down* if occaſion requires.

17. There is commonly in or near the *great Port* a *Wicket* 4 Foot *high*, and half Foot *broad*, which ſerves to *ſally out*.

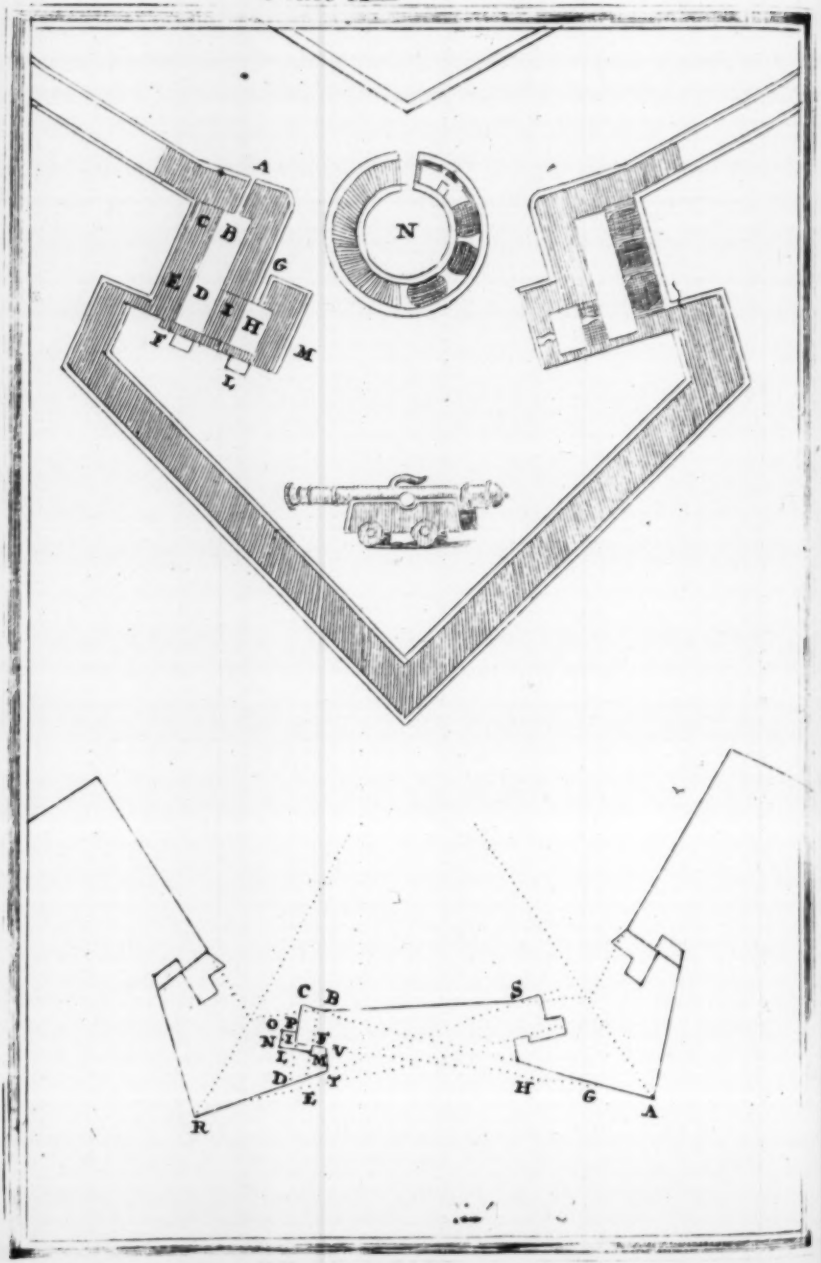
Of Works *that are uſually made within the* Forts, *viz.* Platforms, Cavaleers *or* Mounts, Cazemates, *&c.* See *Plate* XVIII.

Of Platforms. Theſe are the *Plantations* where the *Guns* are laid, and where *Timber* and *Wood* is reaſonable, they are all made of *Plank*, and *Sleepers*

Joyces to lay them upon; otherwiſe there is a *Platform* made for each *Gun*, which is about 8 Foot wide next the *Porthole*, and 14 at the other ſide, the *length* ought to be 18 Foot at leaſt, the *Portholes* or *Embrazures* in the *Parapet* or *Breaſtwork* for the *Guns*, muſt be about 4 Foot wide towards the *Gun*, and towards the *Enemy* or *Campagne* 8 wider, and 16, 18, or 30 Foot aſunder: But if the *Guns* are to play clear over the *Parapet* without any *Ports*, the *Breaſtwork* muſt be abated to 2 Foot and an half, or 3 Foot *high*, and then they commonly uſe *Cannon Basket* filled with *Earth*, which are removed as there is occaſion.

Cavaleers are a great *Body* or *Quantity* of *Earth* above the *Parapet*, raiſed between the *Gorges* of the *Baſtion*, according to *M Mallet*, whereon to plant *Ordnance*, and *Small Shot*, to hinder the *Enemies Approaches*, and to clear the *Faces*, and diſturb the *Batteries* of the *Enemy*. To make it, do thus upon the *Centre*, make a *Circle* with the diſtance of 80 or 85 Feet, which muſt be filled up of *ſolid Earth* about 20 Foot *high*, which if faced with *Brick* or *Stone*, then the *Talu* ſhall not need to be above a *Yard* and 4 or 6 *Inches*, which will make it in the *Diameter* at the top 160 Foot, upon which you muſt raiſe a *Parapet*, &c. as aforeſaid, in the *Rampire*, and then upon the *Terraplane* at the top, you may plant pieces of *Ordnance*, leaving *Ports* or *Embrazures* in the *Parapet*, and making *Platforms*, as was laſt directed.

Plate XIII



Of Cazemates.

Before I give ye the *Meaſures* of my *Cazemates*, I ſhall explain all tne *Parts* of which they are compos'd.

Plate XIII.

A. is the *winding pair of Stairs* to deſcend from the *Rampart* into the firſt *Cazemate*, which is 6 or Foot high above the bottom of the *Moat*; And this is that which I call the *Great Cazemate*.

B. is the *Great Cazemate* ſeen in part by the *Beſiegers*, when they are lodg'd upon the *Level* of their *Parapets* and *Courtains*.

C. is the *Parapet* of that *Cazemate*, 3 or 4 *Fathom thick*, to cover the *Cannon* and the *Cannoneers* from the ſight of the *Counter-Batteries* of the Beſiegers, when they have either *rais'd* or *earth'd* 'em within the *Counterſcarps*.

D. is a part of the *Great Cazemate* wrought farther in, always cover'd and defended by the *great Ear*, and *flanked Angle* of the *oppoſite Baſtion*.

E. is its *Parapet* or *Breaſtwork*, 3 or 4 *Fathom thick*.

F. is the *Magazine* for the *Powder Bullets*, and other *Ammunition* belonging to the *Cazemate*; it muſt be cover'd and hollow'd *inward*, into the ſolid ſubſtance of the *Baſtion*.

G. is the *Pair of Stairs* into the *ſecond Cazemate.*

H. is the *ſecond Cazemate* that lies out of ſight, as being about *two thirds* of it, not to be ſeen by the *Enemy*, though they ſhould come to be lodg'd upon the *Counterſcarps* themſelves.

I. is the *Parapet* of the *blind Cazemate*, 2 or 3 *Fathom thick.*

K. is its *Magazine*, made like the *Magazine* belonging to the former.

L. is the *third Cazemate not ſeen*, and rais'd even with the *Platform* of the *Baſtion.* Upon this may all ſorts of *Artillery* be planted, to ſhoot as well above the *Parapets*, as through the *Holes* that are cut through the *thickneſs* of the *Parapet*, which is from *two* to *three Fathoms.*

M. The *draught* of a *Platform* for the planting of *Cannon*, call'd a *Cavalier*, with its peculiar *Magazine.*

The Structure *or* Manner *of making the* Cazemates, *according to* M. Mallet.

I ſhall not here go about to *entangle* my ſelf in a *vain Diſpute* with thoſe that would have the word *Cazemate* to be derived from the *Spaniſh* words *Caze*, and *mata*, as if we ſhould ſay, *A Houſe of Murder*; And therefore, without more ado, I come to ſhew ye how my own are made.

Suppoſe

Suppoſe the *Baſtions* to be drawn out in *white lines*, that the *Scale* be made *full the length* of one of the ſides of the *Polygon*; and that it be divided into as many equal *Parts* as it contains *Fathoms*, as has been explained at the *beginning* of this Book.

Then extend the *Defence* of the *Baſtion A. B.* from *6* or *7* *Fathoms* at moſt, from *B.* to *C.* from the Point *C.* draw *C. D.* parallel to the Flank *B. E.* then divide the Flank *B. E.* into two equal parts, at the Point *F.* to draw from the Point *G.* which is the middle of the oppoſite Front *A. H.* the Line *G. F.* to the inſide of the *Baſtion*, obſerving where it cuts *C. D.* as in *I.* purpoſely to carry on one *Fathom* from *I.* to *L.* afterwards draw the Line *M. L. N.* parallel to *F. I.* the length of which from *M.* to *N.* muſt be 11 *Fathom*: That done, make *N. O.* parallel to the Flank *B. F.* the length of which from *N.* to *O.* muſt be 4 *Fathom.* Laſtly, make *O. P.* parallel to *F. I.* and then all the void ſpace *B. M. N. O. P. C.* ſhall be the Extent of the *Cazemates*, as well of the large *Cazemate*, as of thoſe which are more private.

To make the *Shoulder* or *Ear* of the *Baſtion*, draw upon the Line of Defence *R. S.* *6* *Fathom* from *E.* to *I.* and upon *F. G.* *6* *Fathom*; alſo from *F.* to *V.* and then joining *V.* and *I.* together, you have the *whole Shoulder* or *Ear F. V. T. E.* which muſt be all one ſolid piece. For the *Parapet* of the firſt *Cazemate*, you muſt allow within ſide 1 *Toiſe* of *height* from 3 to 4 in *thickneſs*, with 8 *firing places* for the planting of ſo many *great Guns*, obſerving that the *Parapets* of the *Cazemates*, more eſpecially all that which is next to the *Gorge*, and lies

lies always hid from the *Beſiegers*, do not require a *length* and *thickneſs* ſo preciſe.

Of the Outworks, *and firſt of a* Ravelin *or* Target.

A *Ravelin* is a Bulk of Earth almoſt like a *Bulwark* cut off lying beyond the *Ditch*, for the covering of the *Courtain*, *Bridge*, or *Gate*, and is ſurrounded with *Water*, and ſeparated from the *Fortification* by the breadth of the *whole Ditch*; it is raiſed but a little *height* above the level of the *Ground*; towards the *Enemy* 'tis built with a *Rampire* and *Breaſtwork*, but lies open towards the *Fortification*.

The making of them is Various. Plate *XIV.*

The *Ravelin A.* is thus made, lengthen out the *middle Line* of the *Courtain o. m.* then take with your *Compaſſes* the length of the *Courtain B. C.* and ſetting one Foot in *b.* and *c.* deſcribe the *Arch* at *d.* then from the Point *d.* draw black Lines to the *Angles* of the *Flank* and *Face f. e.* where they interſect the *Counterſcarpe*, as at *h. g.* ſhall be the *Faces* of the *Ravelin* from *g.* and *h.* to the interſection of the *Counterſcarpe Line* and *Middle Line* of the *Courtain g.* at *i.* draw the *Lines g. l.* and *h. i.* for the *Demigorges*, ſo is the *Out-ground Line* of the *Ravelin* made. The *upper thickneſs* of the *Rampire* may be 30 Foot *thick*, and about 6, 7, or 8 Foot *high*, on which there may ſtand a *Parapet* equal with that on the *Rampire*; And the *Profiles* and *Meaſures* are made after the ſame manner as thoſe of the *Rampire*.

The

Plate XV

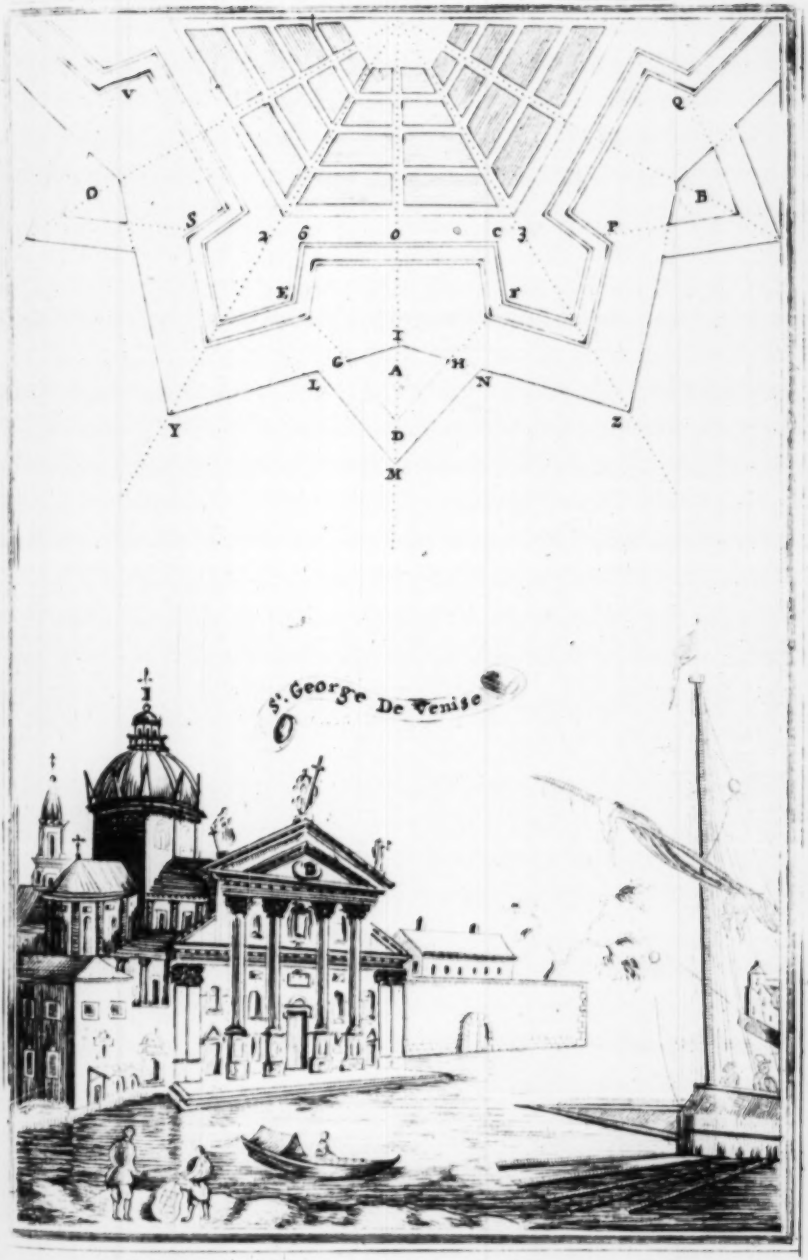
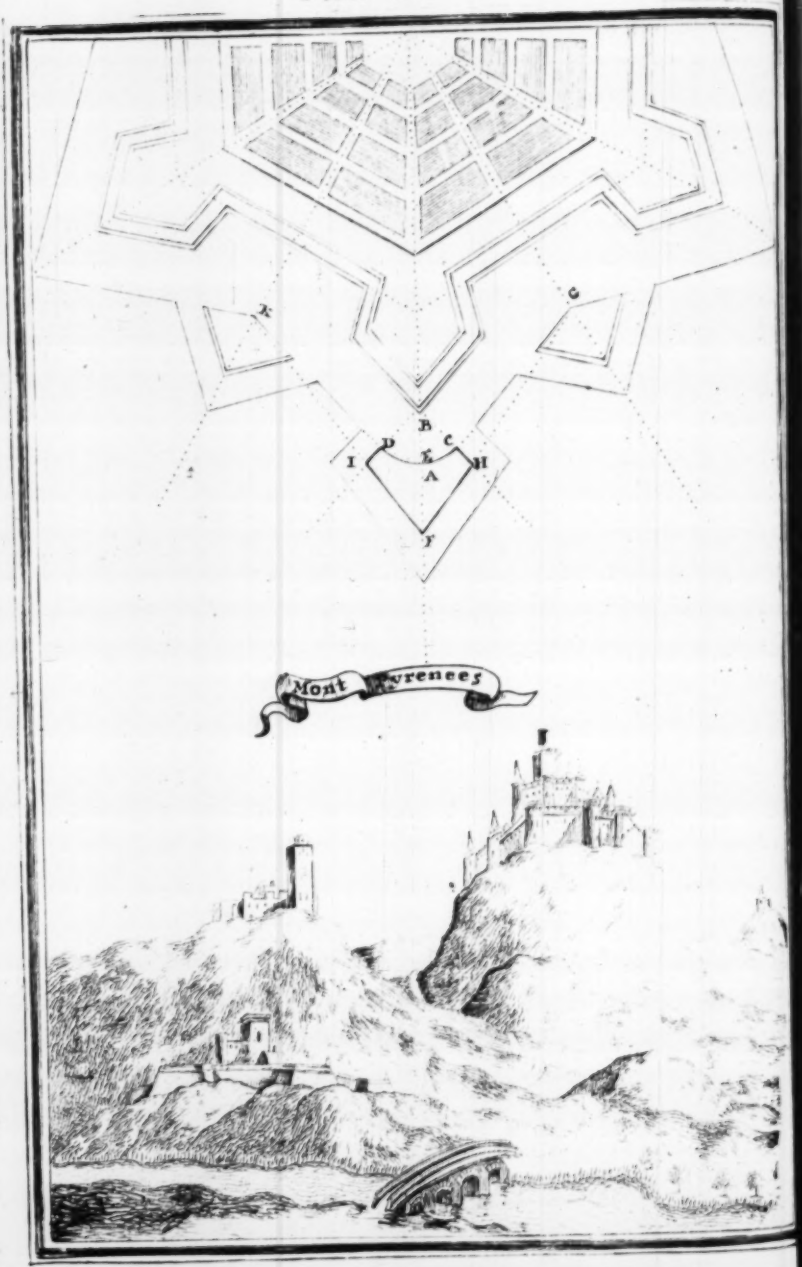


Plate IV



The *Moat* about the *Ravelin* may be about half the *width* of the *great Moat*, *M. Mallet* makes it half the *Flank* drawn parallel to *g. d. h.* as *l. m. n.* for the *breadth* of the *Moat*.

If you would make the *Ravelin* more *close* and *compact* as *B.* draw the *Lines p. q.* to $\frac{2}{3}$ of the *Flank*, or if more as *c.* then draw the *Line r. s.* to $\frac{1}{3}$ of the *Flank*.

Another way, divide the *Gorge Lines* 2. *b.* and *c.* 3. from which *Points* draw ſtrait *Lines* through the *Flanks*, till they meet one another in the *Point m.* then produce the *marginal Lines* of the *Ditch*, *y. l.* and *z. n.* till they meet in *i.* and cut the former *Lines m. g. h.* ſo ſhall *i. g. d. h.* be the *Ravelin* required.

Of the Halfmoon *or* Helmet. *Plate* XV.

Halfmoons do not differ much from *Ravelins*, they are built before the *Angle* of the *Bulwark*, and are arched in form of a *Creſcent* on that ſide which lies towards the *Bulwark*, and are placed upon the *Covert way* which is beyond the *Ditch*, ſo that their *Capital Line* produced, cuts the *Courtain* into two equal parts.

Let not their *Angle* be leſs than 60 degrees, nor more than 90.

Prolong the *Capital Line B. F.* then upon the *Point B.* and with the diſtance *B. C.* deſcribe the *Arch C. e. d.* then draw out the *Lines* from the *Faces* of the *Baſtion B. I. B. H.* then from the two *Ravelins* deſcribed as before *G. K.* produce the *Lines G. H. S. K. I.* till they meet in the *Point F.* ſo ſhall *H. F.* and *I. F.* be the two *Faces* of the *Halfmoon*.

Ta-

Taquet tells us, 'tis the *weakeſt* of all the *Outworks*, ſeeing it cannot entertain a *good quantity* of *Soldiers* to defend it, by reaſon of its *ſtraits*, and is alſo with more difficulty *defended* from the *Fortification*, therefore there ought to be *Ravelins* built on both ſides; And that they *conſiſt* only of *Faces*, being altogether without *Flank*, otherwiſe being poſſeſſed by the *Enemy*, they cannot be *commanded* from the *Ravelins*, and ſaith 'tis ſtill doubtful whether they are *uſeful* or not, and that the *greateſt uſe* of them is in *Irregular Fortification*.

Of the Tonges *or* Tenailes. *Plate* XVI.

Tenailes are *Outworks* of two ſorts, the firſt having only an *external Angle*, which is called the *ſingle Tenaile*, viz. *R.* the other is called the *double Tenaile*, becauſe it hath two *outward Angles* with one *inward*, viz. *N.*

Theſe are ſeldom made *uſe of*, unleſs when ſome *ſudden occaſion* urges, for the defect of all *external* or *ſaillant Angles*, is that about the very *Angle* it affords the *Enemy* a certain *Quadrangular ſpace* within, which ſhelters them from the *Shot* of the *Defendants*, therefore ſome *Ingeniers* propoſe it neceſſary to raiſe a *Ravelin* before it; And the *double Tenailes* will likewiſe *double* the *defect*, ſeeing they are made with a *double outward Angle*, therefore are not laid before *Bulwarks*, by reaſon of their *weakneſs*.

But the Author of *Travax de Mars* tells us, That theſe *Tenailes* are very proper to *encloſe* a large ſpace of *Ground* which may annoy the *Town*, or where the *Enemy* may lodge himſelf; And that the

Plate XI

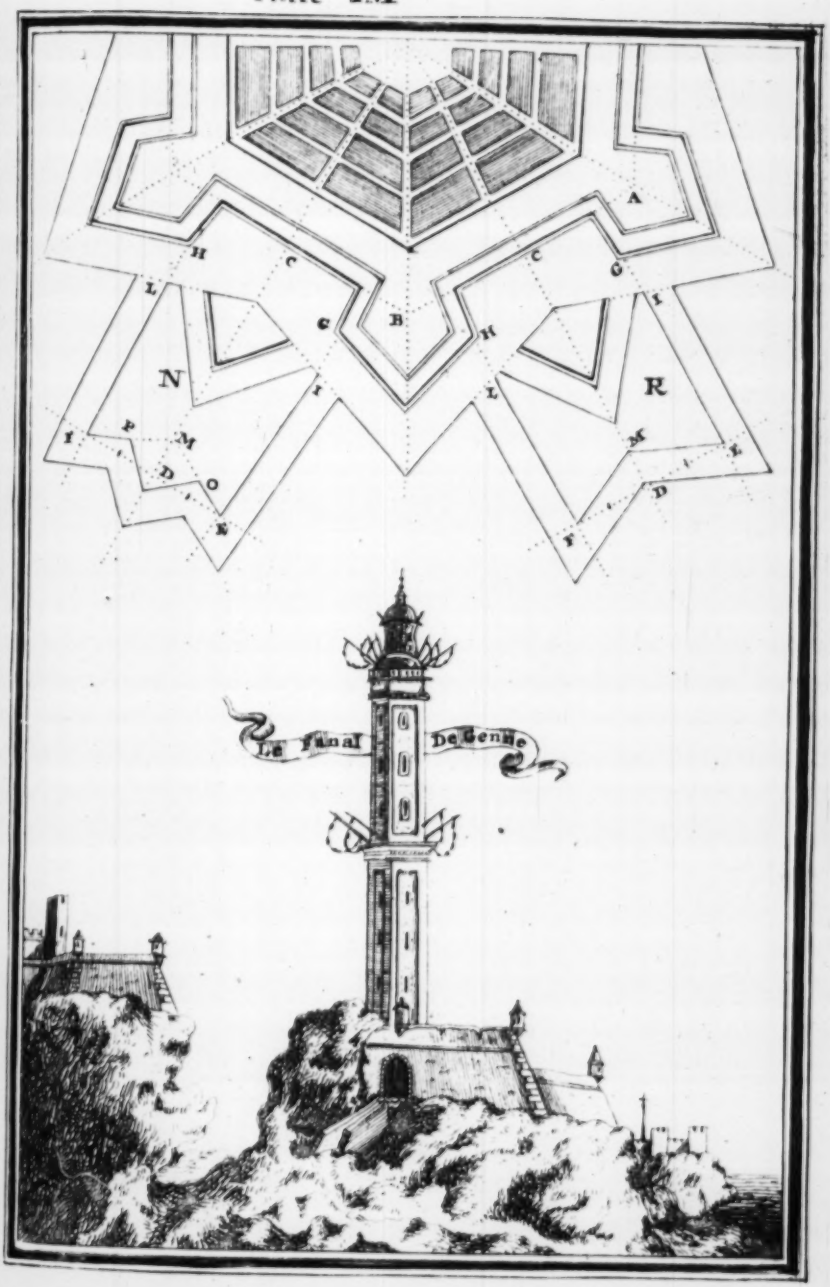
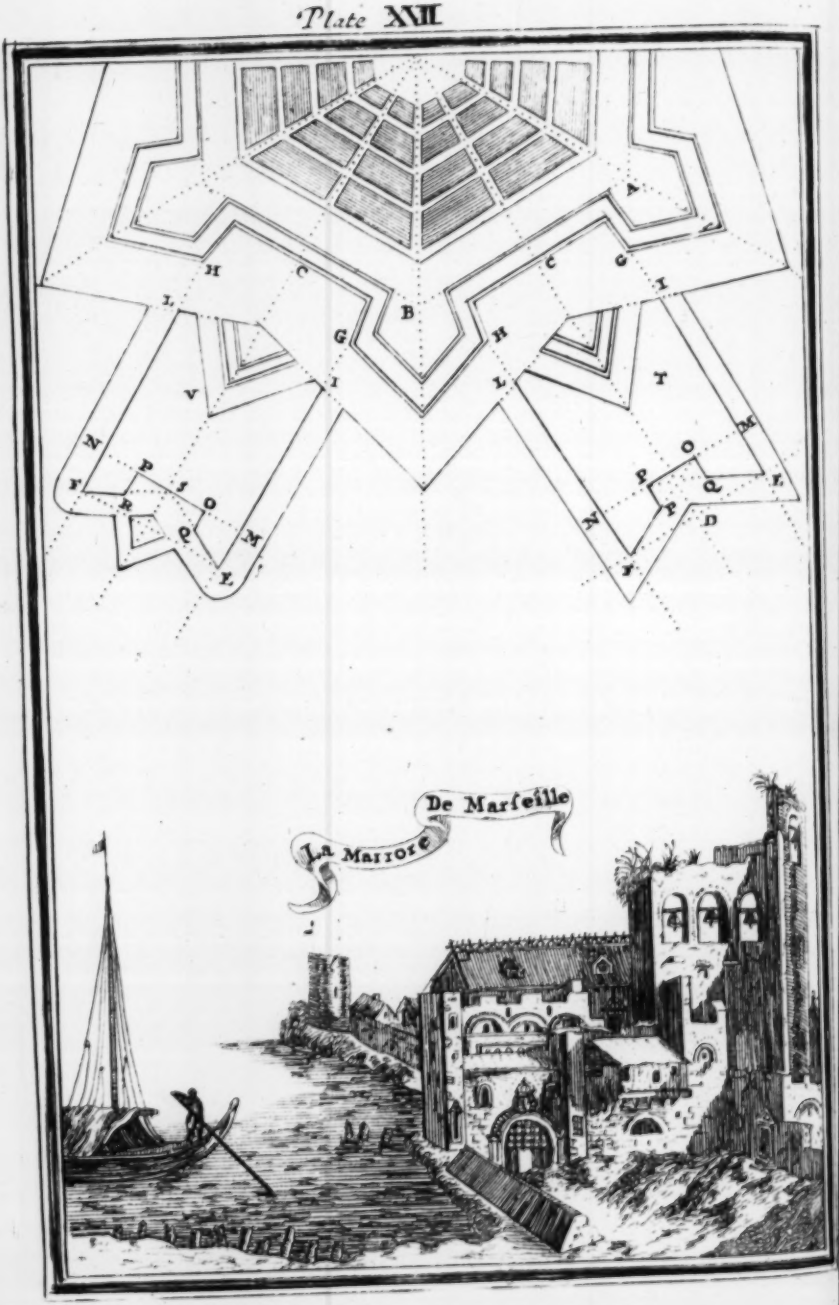


Plate XVII



the *double Tenaile* is much more *advantageous*, by reaſon of its *ſaillant* or *outward Angle*, which is much better for *Defence* than the *rentrant* or *inward Angle* of the *ſingle Tenaile*: He alſo allows the *Sides* to be 120 *Toiſes* from the *Faces* of the *Baſtions* to their *Extremities*.

To raiſe or deſcribe the *ſingle Tenaile R.* take the *length* of the *Polygon A. B.* and ſet it off upon the middle of the *Courtain Line* from *c.* to *d.* then upon the *Point d.* draw the *Line E. F.* parallel to the *Courtain*, then prolong the *Flanks* till they interſect that parallel *Line* in *E.* and *F.* ſo have you the *Sides* of the *Tenaile*, which muſt end upon the *Counterſcarps* at *I.* and *L.* then divide *d.* and *e.* into two equal parts, and ſet one off from *d.* to *m.* then joyning *E. m.* and *F. m.* you have made your *ſingle Tenaile*.

To make the *double Tenaile N.* divide *M. E.* and *M. F.* exactly through the *middle* at *o.* and *p.* then take the *half* of *D. m.* and ſet it off to *g.* then join *F. P. Q. O. E.* which ſhall be the *double Tenaile*.

Their *Rampires*, *Parapets*, and *Moats*, together with their *Covert ways* and *Sloapings* are made according to the ſame *meaſures*, and after the ſame manner as thoſe of the *Ravelins* and *Half-moons*.

Of Hornworks. *Plate* XVII.

Theſe are built *oppoſite* to the *Courtain*; if they cover the *whole Courtain*, as ſome will have it, their *Defence* will be from the *Faces* of thoſe *Bulwarks* that the *Courtain* lies between; if it does not cover

cover the *whole Courtain*, as others will have it, the *Defence* of the *Sides* will be greater, *viz.* both from the *Faces* of the *Bulwark*, and from part of the *Courtain*.

To delineate theſe Works *T. V.* ſet off the *length* of *A. B.* upon the *middle Line* of the *Courtain* from *C.* to *D.* then at *D.* draw the *Line E. F.* parallel to the *length* of the *Courtain*, then from the *Points E. F.* draw your *Sides* to the *Flanks* of the *Baſtions G.* and *H.* which *Sides* ſhall terminate, where they cut the *Counterſcarpe* in *I.* and *L.*

For the *Work* or *Horn* marked *T.* divide *E. F.* into three equal parts, and for the other *Hornwork* marked *V.* divide *E. F.* into four parts, then ſet off one of theſe parts from *E.* to *M.* and from *F.* to *N.* and draw the *Line m. n.* which muſt be divided into three equal parts *m. o. o. p. p. n.* then draw the *Defences F. O.* and *F. P.* and at the *Point O.* raiſe the *Perpendicular o. q.* or, according to *Mallet*, make it an *Angle* of 98 deg. the *Point* where the *Line O. Q.* cuts the *Defence E. P.* as in *Q.* ſhall give the *Face E. Q.* and the *Courtain O. P.* then transfer the *Face E. Q.* upon the other *Line* of *Defence* from *F.* to *R.* and the *Flank R. P.*

Theſe *Fortifications* ſerve to the ſame *end* as the former, either to *encloſe* any piece of *Ground*, or *oppoſe* any riſing or advantageous *commanding place*, and are much more *in uſe* than the *Tenailes*, *Swallow Tails*, or *Prieſt Bonnets*, eſpecially being to *ſecure* any place, the *loſs* of which would much *endamage* the Body of the *Gariſon*. The firſt of theſe *Works* is alſo more in *uſe* than the ſecond, becauſe the *Flanks* of it are more *large* and *able* to contain a greater number of *Guns*, nevertheleſs

the

the laſt of theſe *Works* is made uſe of in *Cities*, to which the *Wayes* and *Avenues* are not well *diſcovered*, for then they place the *middle* of the *Courtain* in the *High-way*, and many times *ſecure* it with a *ſmall Ravelin*.

How to raiſe the Forts *call'd* Swallows Tails, *and* Prieſts Bonnets. *Plate* XVIII.

The raiſing of theſe *Outworks* differs nothing from that of the preceding *Tenailes*: Therefore to raiſe them, place the *length* of the *Side* of the *Polygon A. B.* upon the *Centre Line* which paſſes through the *middle* of the *Courtain* from *C.* to *D.* and at the *Point D.* draw another *Line* parallel to the *Courtain*, which ſhall terminate from *D.* into *E.* and from *D.* into *F.* through the half of one *Courtain* of the place.

For the *Sides*, draw them through the *middle* of the *Courtain C.* and obſerving that they *cut* the *Counterſcarpe* at *R.* and *S.* they ſhall there *terminate*; ſo that dividing *D.* and *E.* into two equal parts, and ſetting one of theſe parts from *D.* to *M.* upon the *Line* of the middle of the *Courtain*, join after that *M. E.* and *M. F.* and you ſhall have the *Swallow's Tail*.

For the *Prieſt's Bonnet N.* after you have drawn the *Sides*, and made the *re-entring Angle*, as above, you ſhall divide the *Lines M. E.* and *M. F.* exactly in the *middle* at *O.* and *P.* and ſetting off one of its parts from *D.* to *E.* then joining *E. O. Q. P. F.* you ſhall have the *Head* of the *Prieſts Bonnet*. The great *Sides E. T.* and *T. V.* terminate upon the *Counterſcarp* of the *Work*, if there be any belonging to it.

Their

Their *Ramparts*, *Parapets*, *Mouſe-ways*, *Moats*, *Covert-ways* and *Slopings* are made as in the *Forts* preceding.

OBSERVATION.

Theſe *Forts* were invented to *encloſe* the *Sources* of *Springs*, *Churches*, *commanding Places*, and the like, which only *extend* in breadth, the *loſs* of which may prove a *great prejudice* to the *Inhabitants*, and annoy the *Defences* of the *Town*. And both theſe and the *preceding Works* are rais'd according as the *Ground* will bear, and not according to any *certain meaſures*, with this farther Remark, *That they ought to be commanded by thoſe Places that are neareſt the Body of the Gariſon.*

The Raiſing of Crown-works.

If the *Crown-work* is to be ſet before the *Courtain*, then it is rais'd by prolonging the *Centre Line*, which paſſes through the *middle* of the *Crown*, the *length* at moſt of one ſide and an half of the *Polygon* from *A.* to *B.* then at the *inward* of the entring *Angle* of the *Counterſcarp C.* and at the *Diſtance C. B.* make the *Arch* of a *Circle D. B. E.* then place upon it on the each ſide of *B.* the *length* of the *Courtain*, and a *Demigorge* in *F.* and *G.* then draw the *ſtrait Lines F. B.* and *B. G.* from one *Point* to the other, ſo have you the *exterior Polygons* of the *Crown*. Then draw the *Lines*, or great *Sides* of the *Crown* from the *Angles* of the *Flanks K.* and *Z.* belonging to the main *Fortification*, and that ſo as to *terminate* upon the *Counterſcarps* at the *Points*

Points H. and *I.* afterwards divide the *Line B. F.* into 3 equal parts, and place one of theſe parts from *B.* to *M.* and from *F.* to *L.* and from *G.* to *N.* upon the *long ſides*, that you may have room to draw the inner *Polygons L. M.* and *M. N.*

To deſign the *Demi-Baſtions*, which have always their *Gorges* equal to their *Capitals*, take *F. L.* and place *L.* in *O.* and *N.* in *P.* upon the inner *Polygons* for the *Gorges*. For the *Demigorge* of the *Baſtions M. X.* and *M. Y.* they are made of the 5th part of *M. L.* then from the *Extremes* of the *Capitals F. B. G.* draw the *Defences*, containing one third of the *Courtain*, *B O. B P.* and *G Y.* and *F. X.* and at the *Point O.* with a *Line* of *Chords* or *Semicircle*, make the *Angle X. O. Q.* of 98 degrees, and mark out where the *Line O. Q.* cuts the *Defence F. X.* in *Q.* to the end you may have *F. Q.* for the *Face*, and *Q. O.* for the *Flank*, and ſo the *Half Baſtion* ſhall be finiſhed, as ſhall the other alſo, *obſerving* the ſame *Rules.*

To make the *Baſtion*, make at the *Point X.* the *Angle* of the *Flank O. X. S.* of 98 degrees, to mark out upon the *Defence B. O.* the *Face B. S.* and *S. X.* ſhall be the *Flank*, as well as *X. O.* the *Courtain*; and ſo continuing the *ſame method* on the other ſide, the *Crown* will be compleated; adding to it the *Ramparts*, *Parapets*, *Moats*, *Covert-ways*, and *Slopings*, as has been directed in the *preceding Pages.*

OBSERVATION.

This *Fortification*, by reaſon of its *largeneſs*, is to be preferr'd before all the *former* by us deſcribed, eſpecially if it be to *encloſe* any *Suburb*, *Convent*, or *Palace* of conſequence; and if any *Road* of the *City* paſſes into the *Crown*, it will be requiſite to raiſe a *Ravelin* before the *Courtain* of the *Crown-work*, as in the *Plate* XIX.

The Raiſing of Crowned Hornworks. *Plate* 20.

The *Horn* being deſign'd, as I have directed *p.* 78. To make the *Crown*, take two thirds *A. B.* of the *breadth* of its *Head A. C.* or its *exterior Polygon*; and from the *Points A.* and *C.* make two *Arches*, which muſt *cut* themſelves in *D.* and from the *Point D.* draw the *Lines D. A.* and *D. C.* which muſt be *divided* into 3 equal parts, and at the firſt *Points* on the ſide of the *Half Baſtions E.* and *F.* draw the two *Lines E. G.* and *F. H.* parallel to the *Faces* of the *Half Baſtions*, which ſhall *terminate* from *E.* into *I.* and from *F.* in *L.* the *length* of *E. D.* and *F. D.* then at the *Point I.* and at the *Diſtance I. E.* draw the *Arch E. M.* which ſhall *terminate* in the opening of the *Compaſſes* from *E.* in *N.* To draw *O. N.* at the *Point N.* draw *N.* 2. below the *Capital* of the *Half Baſtion* to have *N. X.* upon the *Counterſcarp*. The ſame is to be *done* on the other ſide, *that is*, at the *Point L.* as the *Centre* and the *Point* alſo of the *Diſtance L. F.* draw the *Arch H. O.* upon which reſting the other

limb

Plate XIX

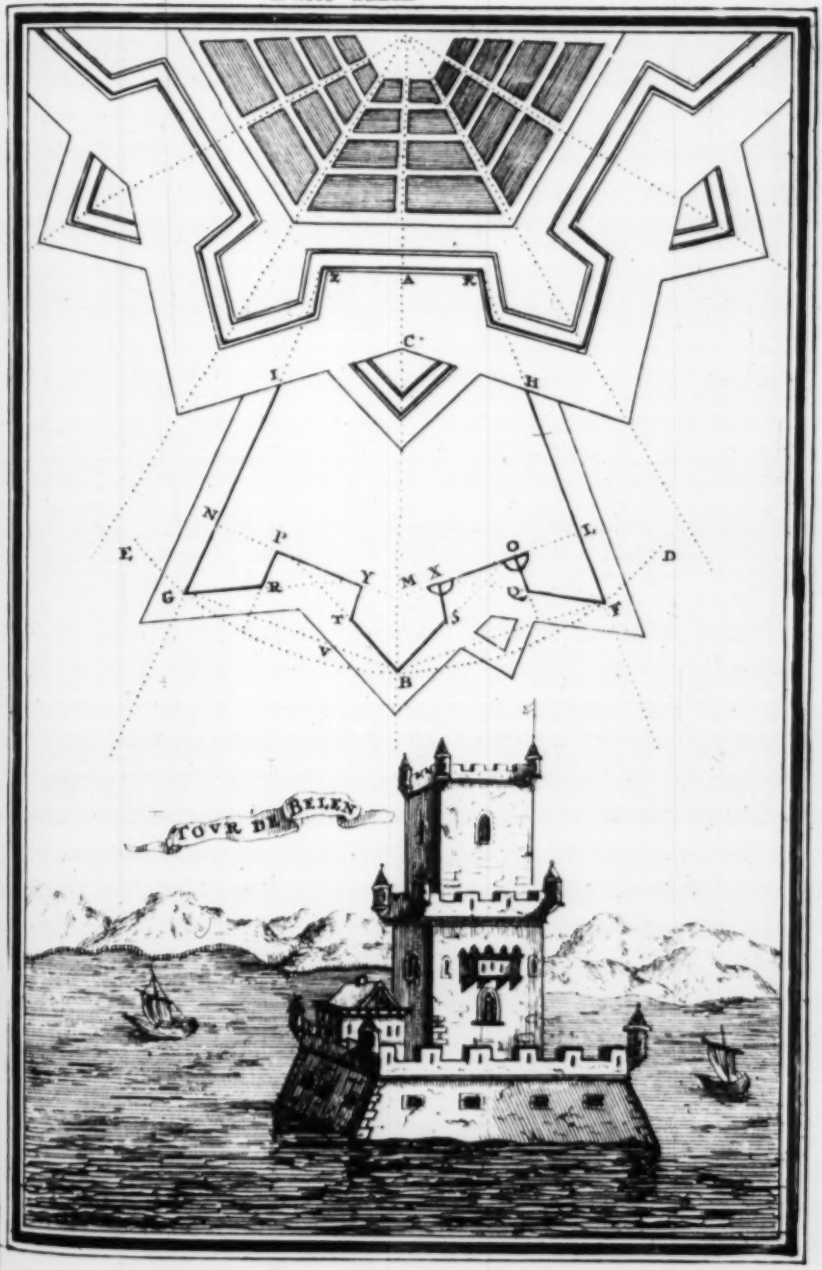
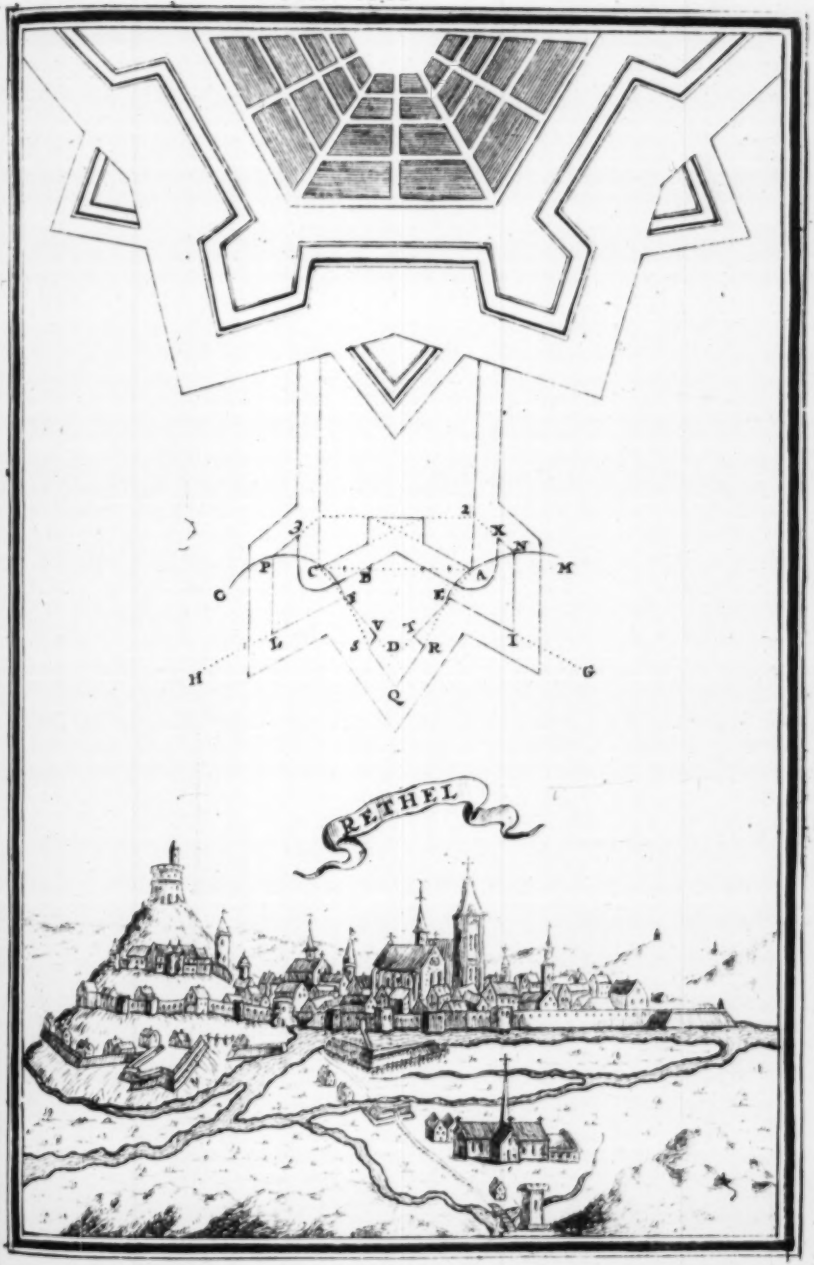


Plate XX



limb of the *Compaſs* from *F.* to *P.* you may draw the ſide *L. P.* and make *P.* 3. like *N. X.*

For the *Baſtion*, the *Capital D. Q.* is made of the *Half* of *D. E.* and the *Demigorge D. T.* and *D. V.* are made of the third part of *D. E.* ſo that in drawing the *Defences Q. E.* and *Q. F.* and making at the *Point T.* the *Angle E. T. R.* of 98 degrees, the *Interſection* of the *Line T. R.* upon the *Defence Q. E.* at the *Point R.* will produce the *Face Q. R.* and the *Flank R. T.* then tranſport the *Face Q. R.* upon the other *Defence Q. F.* from *Q.* to *S.* and you ſhall have the *Face Q. S.* and the *Flank S. V.* and ſo the *Baſtion* and the *Fort* will be finiſhed, only adding the *Ramparts*, *Parapets*, *Moats*, *Covert-ways*, and *Slopings*, as hereafter directed.

OBSERVATION.

Take notice that this *Crown-work* never ought to be rais'd *very high*, to the end that if it ſhould be *taken* by the *Beſiegers*, they that are *behind* in the *Hornwork* may command it, and *beat off* the *Enemy*, when they *attempt* to lodge *within* it.

Obſerve alſo, that the *breadth* which we have allowed to the *Moats* of the *preceding Forts*, is only upon *ſuppoſition* that the Ground will *permit* it; For we are ſomtimes *conſtrain'd* to alter our *Meaſures* according to the *nature* of the *Places*, which ſomtimes require *larger*, ſomtimes *leſſer Meaſures.*

Of the Raiſing *of* Square Cittadels, *which are built upon the Walls of the City.* Plate XXI.

Where *Cities* are not very well *inhabited*, it is ſufficient to raiſe a *Square Cittadel*, with a Figure proper to contain a *ſmall ſpot* of *Ground*. Frequently this *ſmall Encloſure* depends rather upon the *neceſſity* and *nature* of the *Ground*, than a *voluntary choice* of the *Figure:* So then the number of *Baſtions* being reſolv'd upon, and the *Centre* of the *Cittadel*, which is always to be the *Centre* of a *Baſtion* from the *Centre D.* and the *Diſtance* between *A.* and *B.* which is two *thirds* of *A. C.* the *Courtain* of the *place*, you are to draw the *Circumference E. H. G. F.* which muſt be *divided* into 4 equal *parts*, to make out the firſt *draught* of the 4 *ſides E. H. H. G. G. F.* and *T. E.* the reſt is to be *done* as is directed, *p.* 39 & 40. which ſhews you how to raiſe any *Fort*. The *Baſtions* being made, the *Cittadel* will be finiſh'd; The *Ramparts*, *Parapets*, *Moats*, *Covert-ways*, and *Sloping Parapet* before the *Covert-way*, and may be made as ſhall be directed hereafter.

OBSERVATION.

I deſign'd this *Cittadel*, and the following *Pentagon*, fortifi'd after the *ancient methods*, to the end that they who meet with *Planes*, where they would not *willingly alter* the Form of the *Baſtions*, may be able to build *Cittadels* in thoſe *places* according to my *Maxims*. Note alſo, That the *Flanks* of the *Baſtions* of the *place* which join to the

Plate XXI.

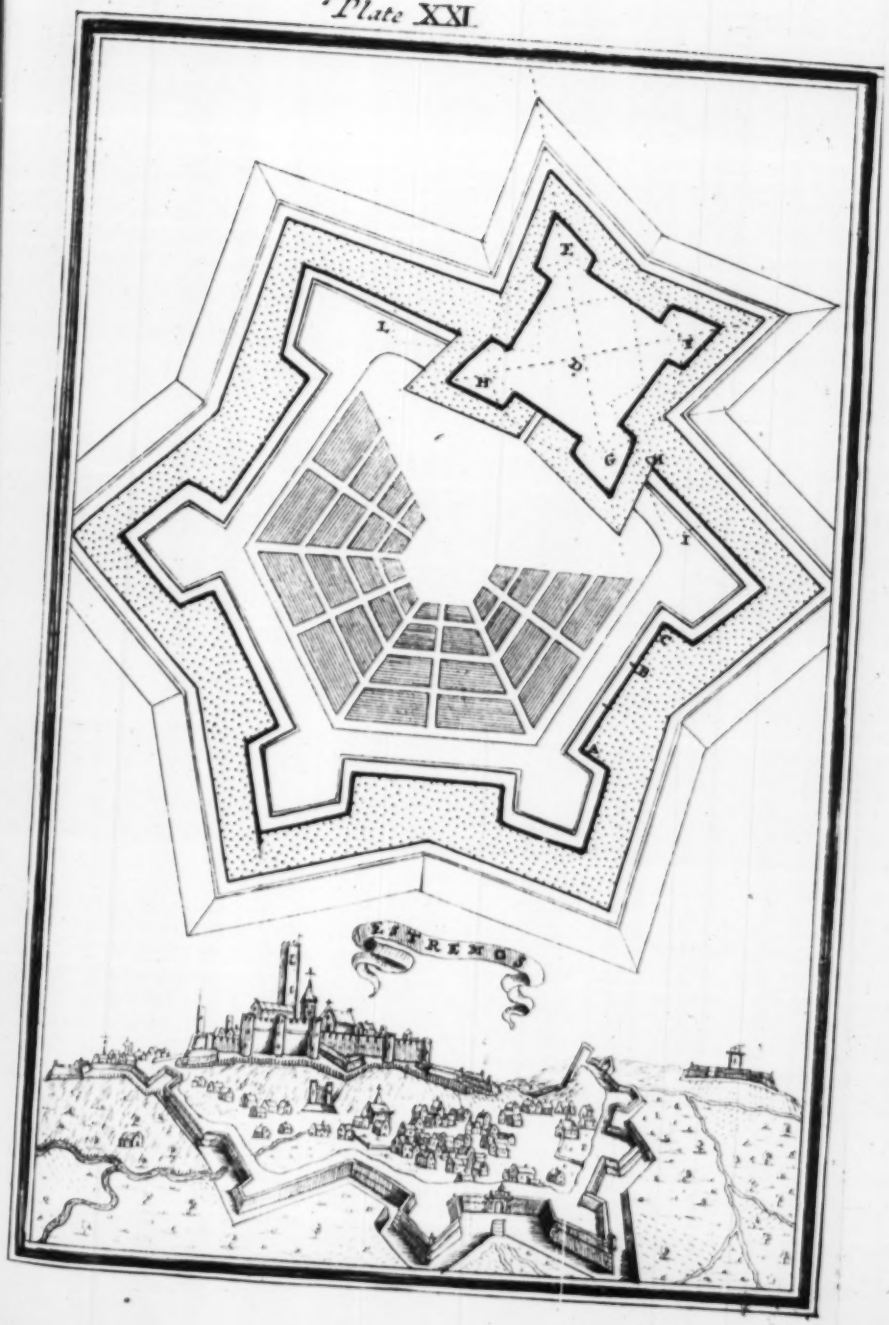
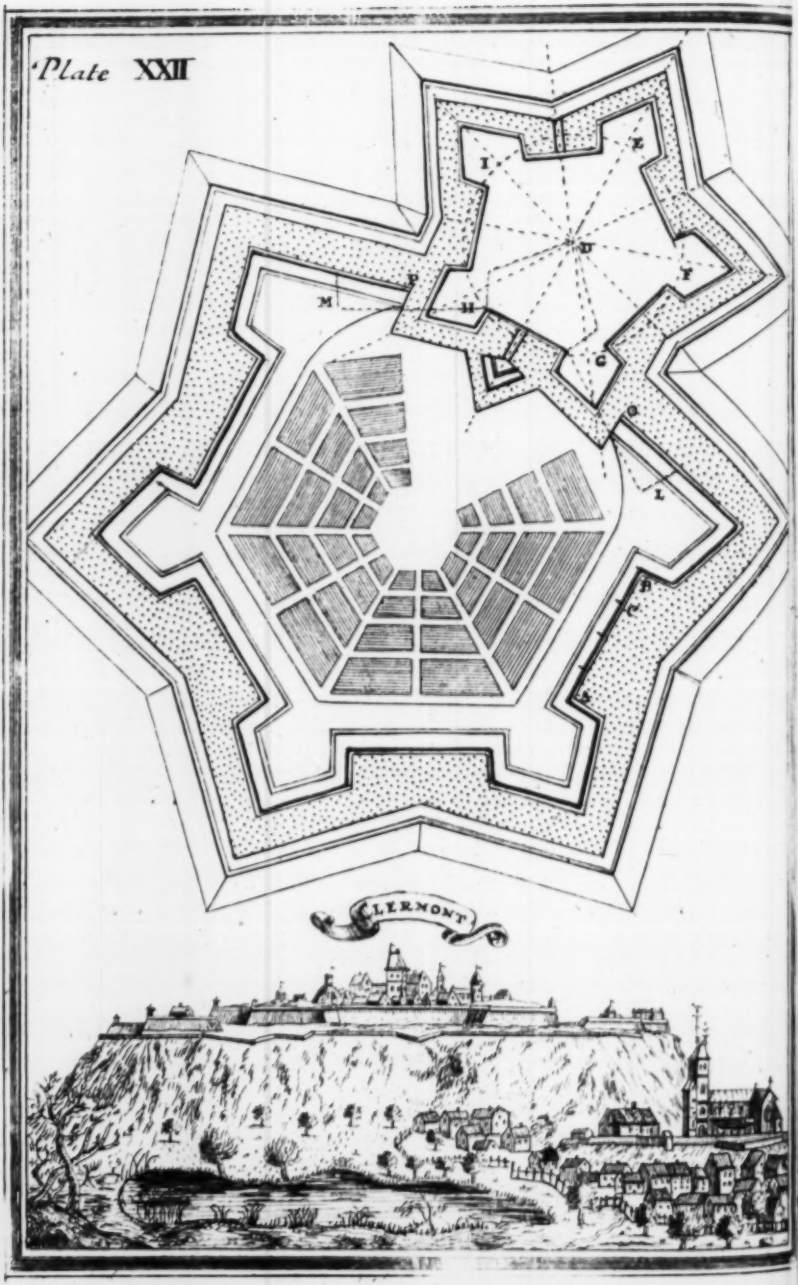


Plate XXII



the *Cittadel* are to be *demoliſhed*, and their *Faces* extended directly with their *Ramparts*, which ought to end inſenſibly *ſloping* at the *Moat* of the *Cittadel*, to the end they may *command* them the more eaſily. The *Cittadels* alſo ought always to be *rais'd higher* than the *City Fortifications*, to the end they may be able to *command* them.

The Raiſing of Cittadels *with five* Baſtions, *which are built upon the Walls of Cities.* Plate XXII.

When *Cities* are well-peopled, and that the *nature* of the *Ground* will ſuffer it, 'tis uſual to lay the *Cittadels* towards the *open Field*, to prevent the ruining of the *Buildings* of the *place*; ſo then after you have *agreed* upon the *number* of *Baſtions*, as here for *Example* upon five to make a *Pentagon.*

Divide one *Courtain* of the City *A. B.* into 4 equal parts, of which *A. C.* comprehends 3. This *Overture* being deſign'd at the *Point* of the *Baſtion D.* draw the *Circumference E. I. H. G. F.* that you may have the 5 *ſides* of the *Polygon E. I. I. H. H. G. G. F.* and *F. E.* putting the *Point E.* directly where the *Circumference* cuts the *Centre Line* of the place, which paſſes through the *Point D.* This will produce two *Baſtions* on the *City ſide*, and three toward the *open Field*, then fortifie this *Pentagon* as is directed *Chap. X.*

This *Cittadel* will be finiſh'd after the *Ramparts*, *Parapets*, *Moats*, *Covert-ways*, and their *ſloping Parapets*

rapets are compleated, as alſo a *Ravelin* juſt before the Gate.

OBSERVATION.

Remember that you are always to *throw down* the *Defences* of the *City* on the *City ſide*, to the end that if the *Inhabitants* ſhould happen to *revolt*, or the *Enemy* to become *Maſters* of it, they may not be able to make *any advantage* of their own *Fortifications*, eſpecially the *Flanks L.* and *M.* which muſt be *ruin'd*, continuing their *Faces* in a *Right Line*, and ſloping down the *Ramparts* to the *Moat* of the *Cittadel*, to the end ſhe may be *able* to command the *whole City*.

Obſerve moreover, That there may be a *great ſpace* between the *Moat* of the *Cittadel*, and the *Houſes* of the *City*; For this *ſpace* is of *great importance* to prevent any *deſigns* which the *Citizens* may have upon the *Cittadel*, as not being able to *approach* undiſcover'd, or *without entrenching* themſelves.

Of Irregular Fortification. Plate XXIII.

Since moſt *Cities* are of an *irregular Figure*, 'tis evident of *what great uſe*, or rather *neceſſity* there is of this part, I ſhall *comprehend* all the matter *briefly*, but *plainly*, in the following *Chapters*.

Firſt, Such *Figures* as have not their *Sides* and *Angles* equal to one another, are called *Irregular*.

Now

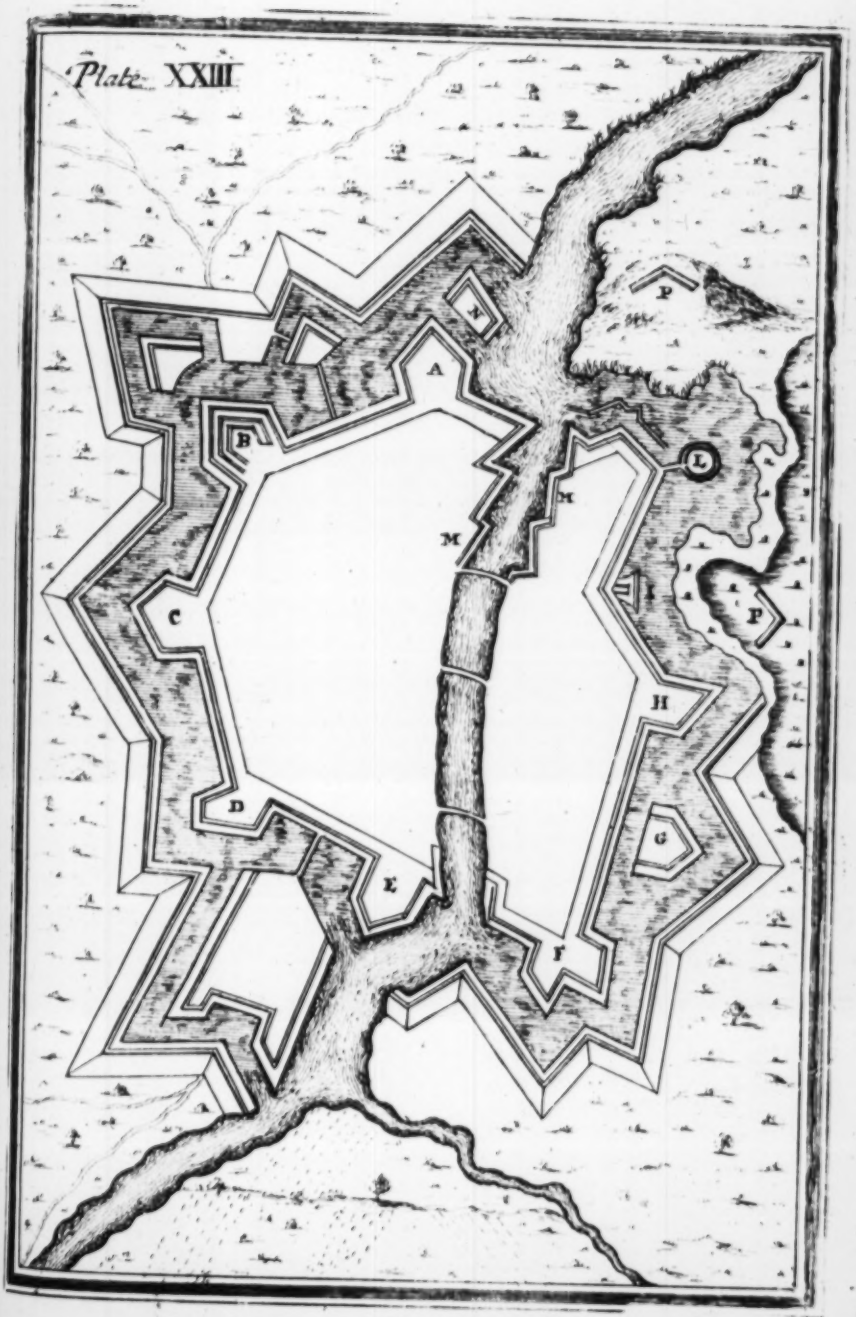


Plate XXIII
N
A
B
C
D
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F
G
H
I
K
L
M
M
P
P

Now forasmuch as the *Forms of Towns* are so various, and subject to so many Cases, their *Fortification* cannot be comprehended under certain *Rules*, neither can the Principles of *Regular Fortification* be exactly observed here; It is therefore requisite that the *Engineer* make a *Map* or *Draught* of the whole, with all the *Ways*, *Passages*, *Rivers*, *Pools*, *Enclosures*, and all other *matters* fit to be known, and then consider what *Designs* and *Works* he shall think most *fit* and *proper* for the place. To this end let him know,

1. That the same *Laws* and *Maxims* for *Regular Fortifications* stand and be in force as for the *Irregular*; and that the nearer an *Irregular Figure* comes to a *Regular*, the *stronger* and *better* it is.

2. That none of the *inward Angles* of his *Figure* be less than 90 degrees; if less, then they must be *changed*, by making the *Point* the outward *Point* of a *Bastion*.

3. That the *Angles* of the *Bastion* be not less than 60 degrees.

4. That the *Line of Defence*, or *Side* of an *Irregular Figure*, must not be more than *Musquet-shot*.

5. The *Side* of an *Irregular Figure*, which is too long for two *Bastions*, and too short for three, may be fortified with two great *Bulwarks*.

6. When the *Side* is above 70 *Rod*, there may

be a *Ravelin* erected between the two *Bulwarks*, or a *flat Bulwark* built between.

7. When an *Angle* of the *Figure* is between 80 or 90 degrees, it ought to be *fortified* with a *Hornwork*.

8. All the difference between *Regular* and *Irregular*, conſiſts in the rectifying the *Sides* that are too *ſhort*, or too *long*, and altering the *Angles* that are *too little*, by cutting off from the *length* what is *too much*, or adding to it what is *neceſſary*, to make them in their *juſt* and *true Proportions*, as in the *Regular*.

More *Rules* might be given, but there being ſo *much Variety* in this ſort of *Fortification*, the *Engineer* muſt practiſe by *himſelf*, by drawing ſeveral *Plats of Irregular Places*, and *fortifie* them. And he ſhould alſo *peruſe* all the *Books* he can get of this *Subject*, as *Marolos*, *Fritach*, *Dogen*, *Dilichius*, *Travax de Mars*, &c. where he will find *Variety of Examples*, which will help to inform his *Fancy*, and rectifie his *Judgment*.

For the Raiſing the *Ramparts*, *Parapets*, and other *Works*, you muſt obſerve the ſame *Rules*, and proceed in the ſame *Method* as in the *Regular*, and no otherwiſe.

And you may alſo *place* all or any of the *Outworks* (mentioned in the *Regular Fortification*) before the *Courtain*, according to the *Rules* there given, only here a greater *liberty* and *latitude* is left to the *judgment* of a skilful *Artiſt*, for the raiſing of the *Outworks* than in the *Regular*; All which you may ſee by the *Explanation* of the *Terms* in the *following Figure*. Plate *XXIII*.

A. Is

A. is a *Regular Baſtion*, and here I ſhall give one *Rule* to find the *Capital Line* in all *Irregular Angles*, viz. at the end of *each Courtain*, as at *e. d.* croſs an *Arch* at *c.* and *f.* and draw the *Line c.a.* which ſhall be the *Capital Line*, which may be about 240 Feet, a *little more* or *leſs*, and the *Gorges* may be 145, or 150 Feet, or *thereabout.*

B. is a *double Baſtion*, that is, upon the *Plane* of the *great Baſtion*, another *Baſtion* is built upon it *higher:* This hath the uſe of a *Cavaleer*, and overlooks the *Campagne*; there may be about 12 or 18 Feet left between the *Parapet* of the *lower Baſtion*, and the *Foot* of the *higher Baſtion.*

C. is a *Baſtion compoſed*, that is, when the two *interior Polygons* are much unequal, then the *Gorges* will be unequal.

D. is a *Baſtion deformed*, that is, if one of the *interior Polygons* be ſo *ſhort*, that it can have no *Demigorge.*

E. is a *Plat Baſtion*, that is, if the *diſtance* from the Points of the *interior Polygon* be double to the *uſual length.*

F. is a *forked Baſtion*, cut off with a *Tenaile*, that is, if the *Angle* of the *Figure* be leſs than 90 degrees; and becauſe of *Water*, or ſome other *Accident* it cannot be *changed*, then you may cut off the *Angle*, and join it with a *Tenaile.*

G. is

G. is a *Baſtion cut off*, that is, ſeparated from the *Rampire*, ſo that its *Gorges* are in a *Right Line* with the two Points of the *Flanks H. F.*

H. is a *Demi-Baſtion*, that is, ſuch as have their *Gorge* and *Capital* equal, and its *Flank* half of the *Gorge.*

I. is a *Platform* upon an *inward Angle*, for the placing of *great Guns* to ſcour the *Ditch.*

L. is a *Mount upon Piles* for a *Corps du Gard*, with a *Parapet* like that of the *Outworks*, *Cannon-proof*, neceſſary to hinder the *Underſurprizes* when the *Moat* is frozen.

M. is an *indented Line*, often uſed upon the Bank of the *Counterſcarp*, or upon a *River.*

N. is a *Counter-Guard* or *Demi-Baſtion*, built in ſome watry place before the main *Baſtion.*

O. is a *Scillon*, or a *Tenaile* with a *Breaſtwork* placed in the *Moat*, called alſo a *Counter-Guard.*

P. is a *Bonnet*, that is, an advanced *Work* like a *Ravelin*, ſomtimes placed on *high Ground*, ſomtimes on *low*, as in the *Figure* XXIII.

CHAP.

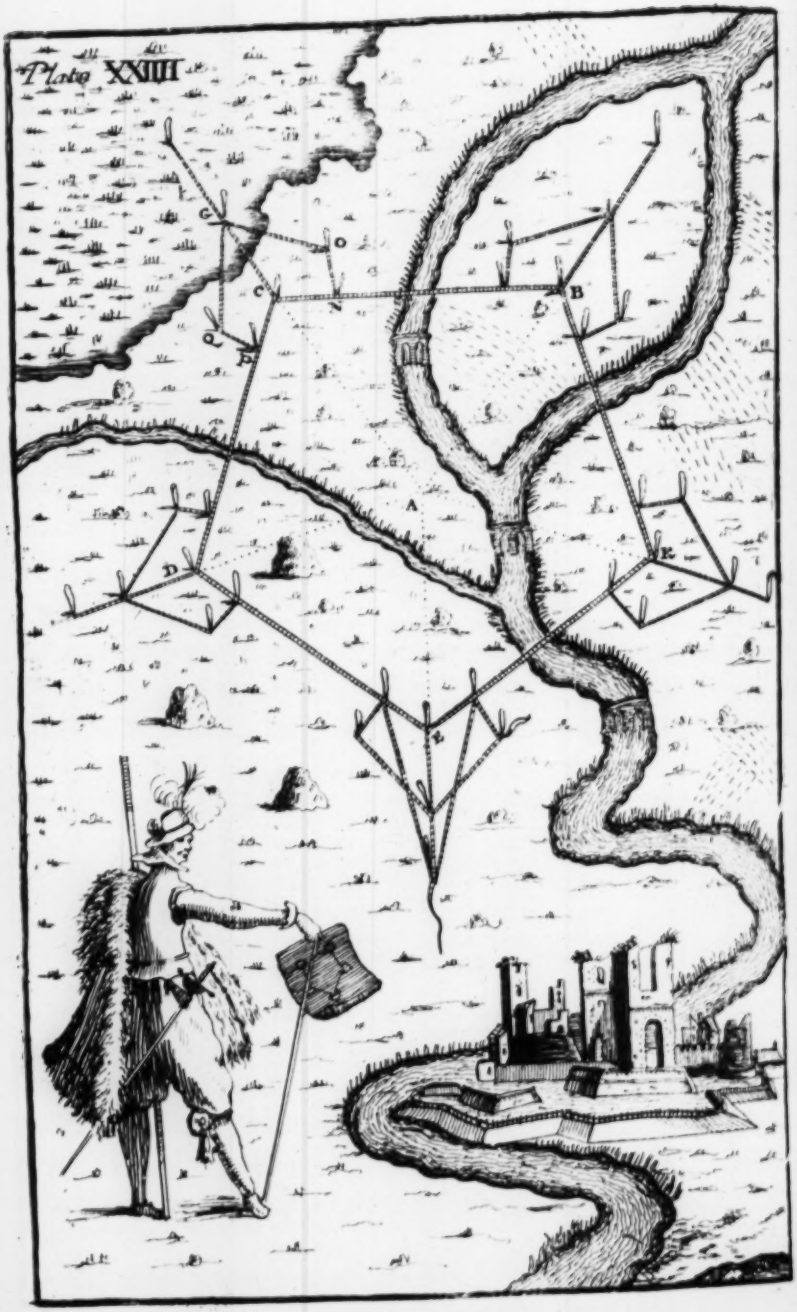


Plate XXIIII
C
O
C
B
Q
P
A
D
E
L

CHAP. XI.

Of laying down upon the Ground *any of the former* Fortifications.

1. YOU muſt have a *Plat* of your *Fort* drawn upon *Paper* very large, ſo that upon each *Line* the *lengths* may be ſet down *Rods* and *Feet*, and the *meaſures* of all the *Angles* particularly expreſſed, as in *Plate* XXIV.

2. Where you extend the *Centre* of your *Fort* as at *A.* there place your *Inſtrument*, whether *plain Table*, *Semicircle*, or *Theodolite*, (if from the *place* all the *Angles* can be ſeen) and from thence ſet out all the *Angles* of the *Centre*, according to the number of the *Sides* of your *Fort* required, which, for *Example*, let it be a *Pentagon*, whoſe *Angles* are alſo 5, and every *Angle* 72 degrees, then fix an *Inſtrument* at *A.* and turning the *Sights* to the beginning of the *Diviſions*, draw out the *Right Line a. b.* as by *Prob.* 1. then turn about the *Sights* 72 degrees, and mark out the *Right Line a. c.* then turn about the *Sights* 72 degrees further, and mark out the *Line a. d.* and ſo for the reſt.

3. Meaſure out the *length* of every one of theſe *Right Lines*, as ſet down in your *Draught*, as with a *Chain* divided and ſubdivided into *Rods* and *Feet*, from

from *A.* to *B.* and from *A.* to *C.* &c. which ſuppoſe to be 68, 52. that is, 68 *Rod*, 5 *Foot*, and 2 *Tenths* of a *Foot*, as in the *Table*, &c. and there ſet *Stakes* at the end of thoſe *Meaſures* which are the *Semidiameters* of the inner *Polygons*, or diſtance from the *Centre*, which being all *ſtaked out*, if you will examine your *Work*, you may meaſure round about from *Stake* to *Stake* the *Sides* of the inner *Polygons*, which by the firſt *Table* is 61. 54. that is, from *B.* to *C.* Then from the *Stake C.* towards the *Stakes* of *B.* and *D.* meaſure the *Gorge Lines C. N.* and *C. P.* which is 13. 26. and ſet a *Stake* at *N.* and *P.* for the end of the *Courtain*, upon which either ſet off a *Right Angle*, (that is, raiſe a *Perpendicular Line*) or elſe an *Angle* greater than a *Right Angle* if required, upon which ſet off the *Flank N. O.* and *P. Q.* 11. 13. meaſure out the *Capital C. G.* 25. 22. upon the *Right Lines* extended beyond *B. C. D.* &c. to *G.* &c. Then draw the *Line G. O.* and *G. Q.* ſo is one *Baſtion* finiſhed, do the like to the reſt *B. F. E. D.* and ſo is your *Fort* lined out for the ſecond *Line*.

But if there be *Houſes* or *Obſtacles* in the way, that from the *Centre* all may not be ſeen, then let *K.* and *G.* repreſent two *Stakes* on the *Ground* where you intend ſhall be the *Heads* or *Angular Points* of your *Bulwarks*. Then placing your *Inſtrument* at *G.* Set off half the *Angle* of the *Polygon K. G. A.* which in this example of a *Pentagon* is 54 degrees. Alſo half the *Angle* of the *Bulwark F. G. C.* which here is 43 degrees, 30 minutes, and in the *Line G. A.* meaſure the *Capital G. C.* ſetting a *Stake* at *C.* for the *Centre* of the *Bulwark*, the

Plate XXV
I
H
L
C
K
Fol. 92. & 93.

the like you may do from *K.* driving a *Stake* at *B.* the *Centre* of that *Bulwark.* Then placing your *Inſtrument* at *C.* mark a *Line* on the *Ground F. C.* making with the *Line B. C.* an *Angle* of 40 degrees, and where it meets with the *Line G. F.* viz. at *F.* there drive a *Stake* for the ſhoulder of the *Bulwark*, and from *F.* let fall by your *Inſtrument* a *Line* on the Ground *F. N.* perpendicular to the *Line B. C.* The like you may do from *B.* and *L.* And thus have you the *Gorges*, *Flanks* and *Faces*, and *Capital.* In like ſort you may proceed and lay down the other *Sides* of this *Pentagon*, and ſo of any other *Figure.* Sundry other ways might be *preſcribed* for drawing out a *Fort*, but any one that is acquainted with *Geometrical Menſurations* will by practice eaſily find them out.

Note, before you *break Ground*, examine all the parts of your *Deſign* or *Draught* which you have *ſtaked out*, by the beſt *Rules* and *Meaſures* preſcribed, and conſider all *diligently* if time will permit, that ſo if any thing may be *amended*, it may be *done* before you proceed *too far.*

How the Dimenſions *and* Draught *of any* Fort *may be taken and delineated.*

Upon four accounts the *Draught* and *Dimenſions* of a *Fort* already built, ought to be taken and deſcribed.

1. When a *Pattern* is to be taken of a *Fort*, to build another like it.

2. To

2. To find out and know what *Charges* the *Buildings* may come to, and whether it be *built* as it was ordered.

3. To know if the *Fort* have its due Defence.

4. In caſe ſome *New Works* are to be added to it, or the *Old Ones* mended.

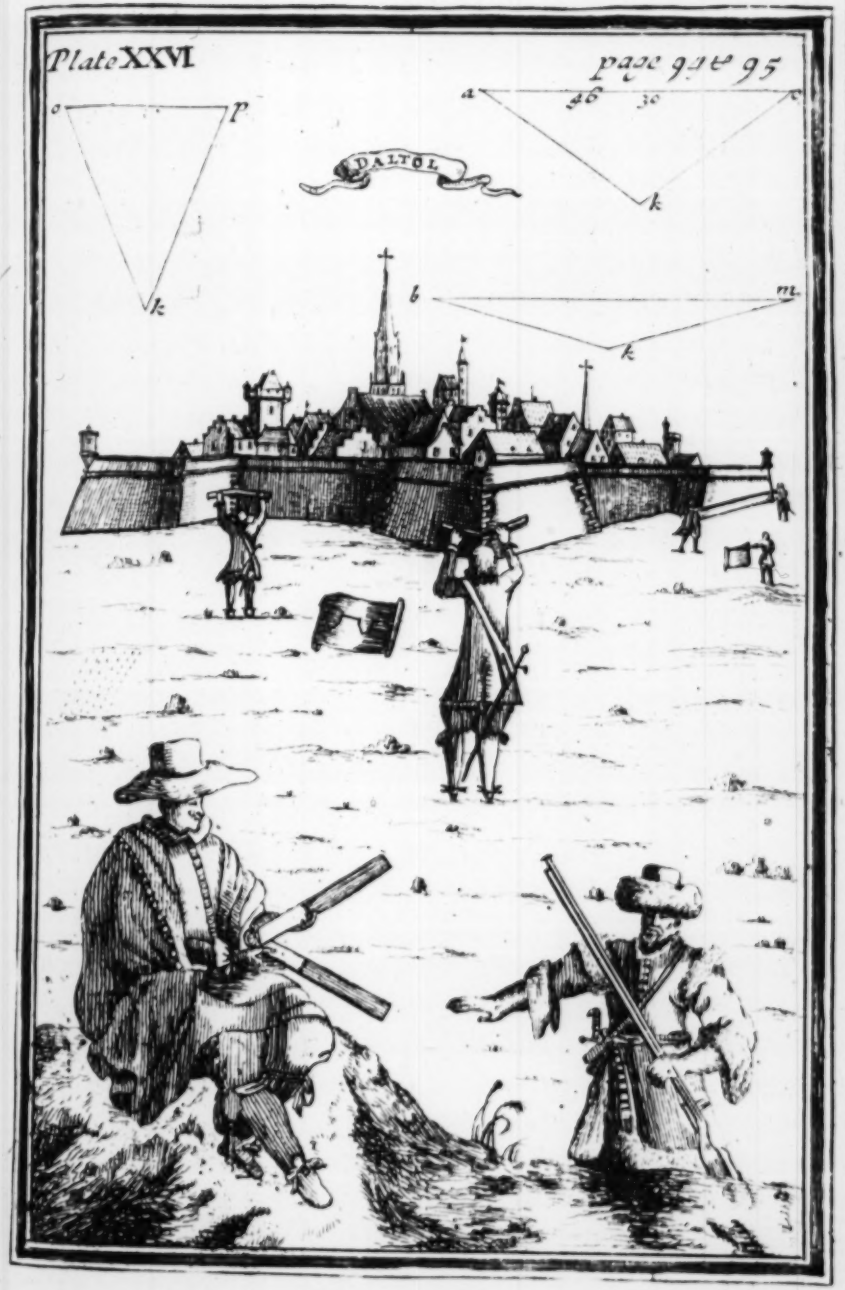
There are ſeveral ways for doing this, our *Author* directs,

1. To meaſure the *length* of the *Face* of the *Bulwark* at its Foot outwardly in the *Fauſſebray*, alſo the *length* of the *Flank*, the *Courtain*; and if the *Fortification* be *Regular*, it is not neceſſary to meaſure the other *Bulwarks*, which muſt be done in an *Irregular Fort*, except you would know whether the other *Lines* be exactly of the ſame *length*.

2. The *Angle* of the *Bulwark* muſt be taken, and the *Angle* of the *Shoulder* by your *Inſtrument*, as in the foregoing *Chapter:* Or if in the *inſide*, you may meaſure any *Angle* with your *Chain*, or *Rod-Pole*, by *Prob.* 8. or by the *Table* of *Angles*, which is of very great uſe where *Inſtruments* cannot be gotten, or muſt not be uſed. Thus having theſe *Data's*, you may delineate it on *Paper* by any of the aforeſaid *Rules* and *Directions*, and if you find all the *Lines* exactly to agree, and join one with another all *round about*, until they meet *together* again, you may be ſure that you have taken your *Angles* and *Meaſures* aright.

Plate XXVI

page 94 & 95



If you would meaſure the *Profile* with the *Parapet*, you muſt meaſure them in the *Ports* or *Gates*, if they be ſo *built* as to *cut* the Wall in the *middle*; but in caſe they are not ſo *built*, you muſt put your *Quadrant* or *Inſtrument* upon the uttermoſt *Point* of the *inward height* of the *Parapet*. And on the other ſide of the *Ditch*, if it be *Horizontal*, or even ground with the *Bulwark*, let another erect a *long Staff* or *Pole*, on the top of which faſten a *black* or *white* mark, ſo as that it may *ſlide* up and down as you pleaſe. Then direct your *Eye* towards the *Staff*, until the *mark* comes into your *ſight*, which you muſt give *notice* of by ſome *certain ſign*. Example:

Suppoſe there were twenty *Foot* from the *Ground* to the *Mark* at the *Staff*, then you may conclude that the *height* of the *Bulwark*, with its *Parapet*, is 20 Foot. Meaſure likewiſe the *inward height* of the *Parapet*, with its *Foot-bank*, which is commonly 6 *Foot*, which ſubſtract from the 20th, and there is 14 *Foot* for the *height* of the *Rampire*. The *exterior Talu* of the *Rampire* may be eaſily found by 3 *Staffs*, of which one is placed *upright*, one repreſents the *Baſis*, and the 3d the *Talu*, which form a *Rectangular Triangle*. Then as the *Perpendicular Staff* is to the *Horizontal Staff*, which repreſents the *Talu*, ſo is the *height* of the *Wall* to the *Talu*. Example:

If the upright *Staff* be 10 *Parts* or *Feet*, and that which repreſents the *Talu* be 5, ſay as 10 to 5. ſo is 14 the *height* of the *Wall* to 7 Foot *Talu*.

To

To meaſure the *Wall*, if the *Gate* be built *crooked* or *bending*, ſo that you cannot *meaſure* at the *Foot* of the *Wall*, you muſt meaſure the *Length* of the *Terraplain* with the *Foot-bank*. And alſo the *inward Talu*, if it be not the ſame with the *height* of the *Wall*, the ſame way as before directed.

Likewiſe you muſt meaſure the *Baſis* of the *Parapet*, and having added *them together*, with the *outward Talu* of the *Rampire*, you will have the *exact thickneſs* of the *Wall*, the *breadth* of the *Ditch*, the *Covert-way*, and the *Counterſcarp*, may be eaſily *meaſured*, by obſerving the *precedent Inſtructions*.

Of the Uſe of the Table *of* Angles *to a* Baſe *of* 30 Feet.

When you would meaſure the *Angle* of any *Field* or *Plot of Ground*, as for *Example*:

Let the *Angle O.K.P.* be meaſured in *Plate* 26. *Fig.* 2. Take any *Line*, *Staff* or *Stake*, and meaſure from *K.* to *O.* 30 of them, and from *K.* to *P.* 30. Then at *O.* and *P.* fix up two *Sticks* or *Stakes*, then meaſure with the ſame *Staff*, *Stick* or *Line*, the diſtance between *O.* and *P.* which ſuppoſe it be $20\frac{1}{4}$ ſeek $20\frac{1}{4}$ in the *Table* in the *Column*, over which is the word *Baſes*, and the number of the next *Column* anſwering to it, is the true number of degrees and minutes of the *Angle* ſought, *viz.* 40 degrees.

After the ſame manner, becauſe the diſtance between *A.O.* is $46\frac{1}{2}$ therefore the *Angle A.K.O.* is 101 degrees, 30 minutes, as will appear by the *Table*.

Sup-

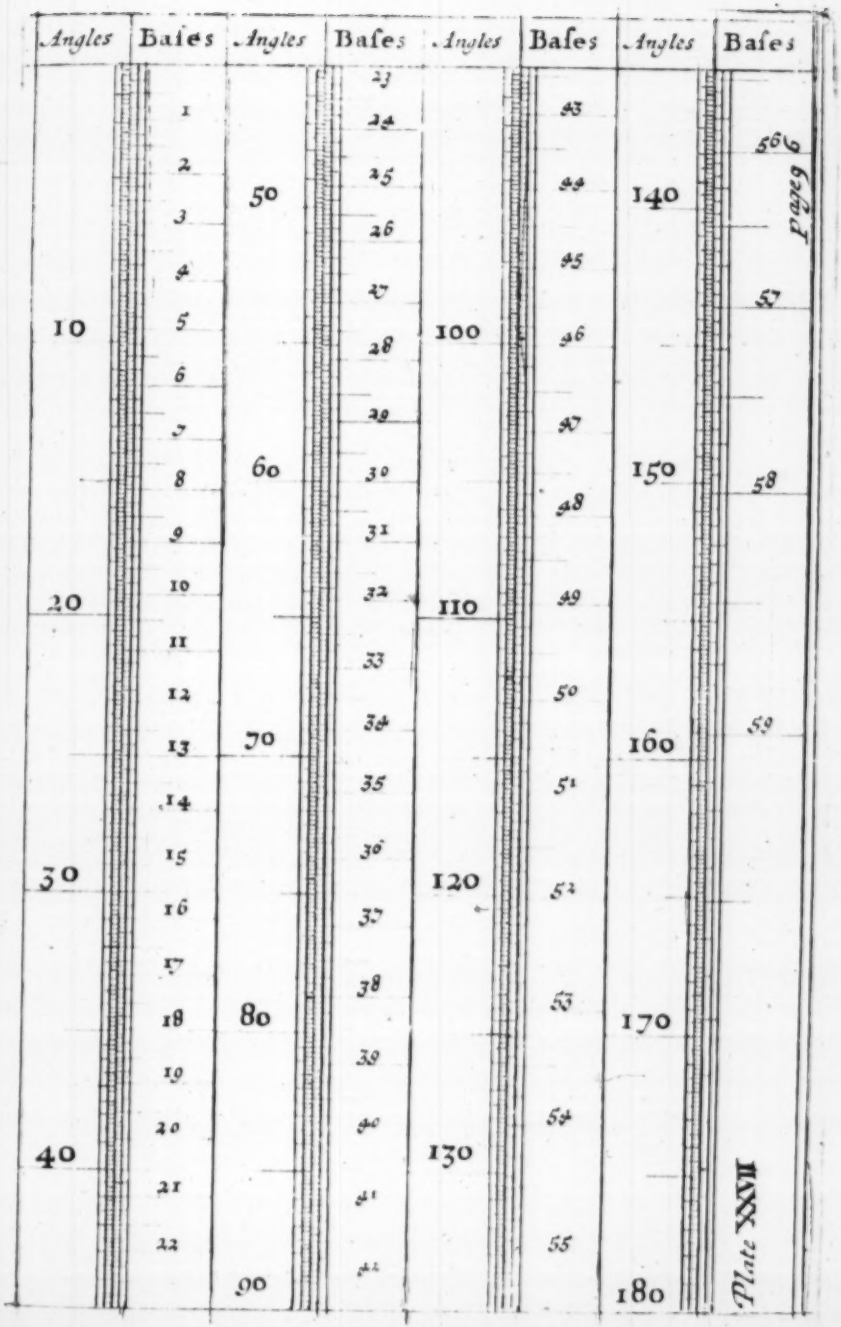

Angles
Bases
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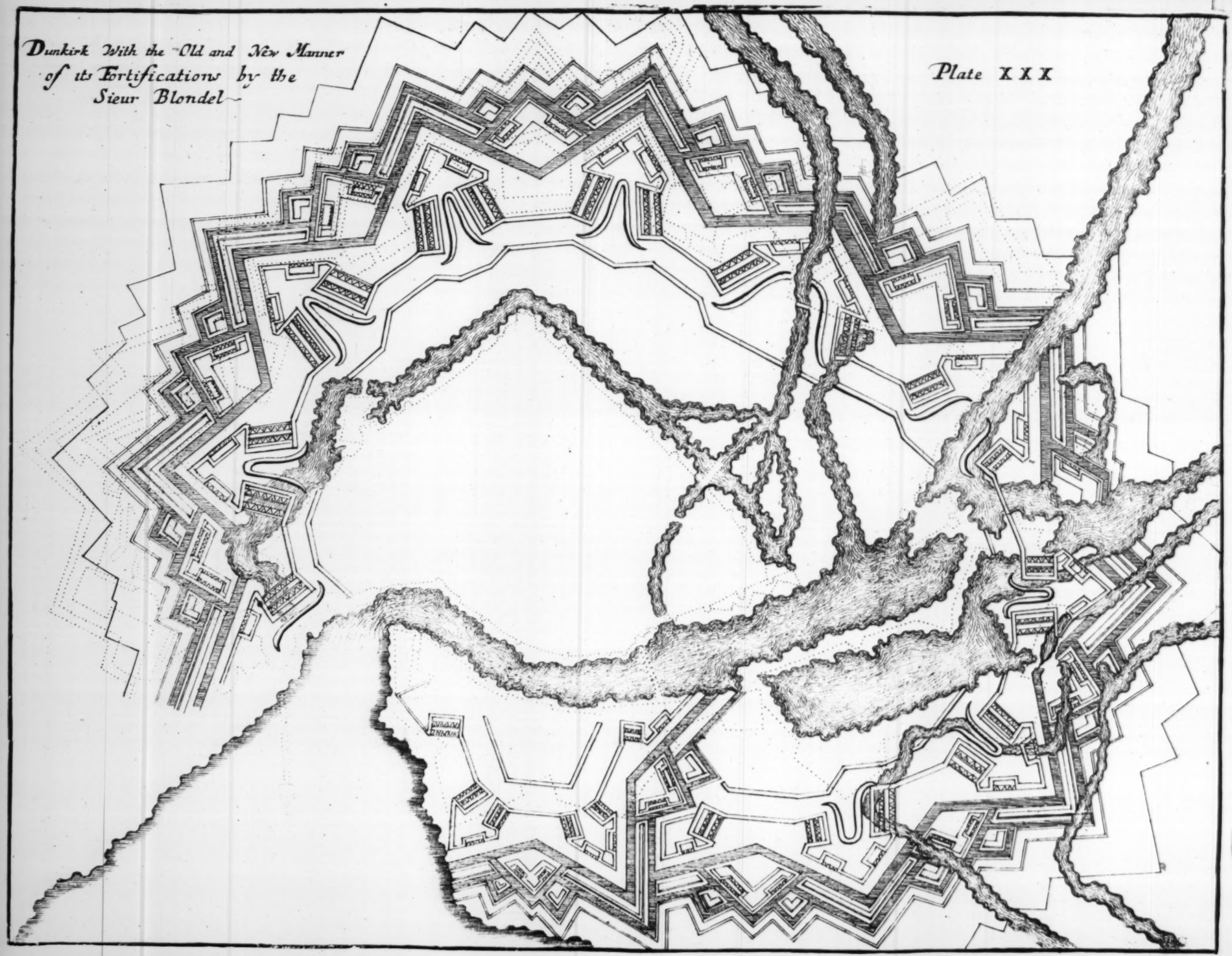
Plate XXVII

Dunkirk With the Old and New Manner of its Fortifications by the Sieur Blondel

Plate XXX



Suppoſe you would lay out an *Angle* of 100 degrees, 5 minutes, firſt ſtick down two *Stakes* or *Sticks* at the *two ends* or *terms* of any *given Line*, as 6 minutes. Then draw a *Line* from *m.* to *k.* and meaſure out 30 equal parts. Then faſtning your *Chain*, *Chord* or *Line* at *K.* equal in *length* to the 30 equal parts. And another *Chain* or *Line* at *m.* look into the *Table of Angles* for 100 degrees, 5 minutes, and you will find 46 to anſwer to it, ſo then cloſe the *two Lines*, and where ever they meet at 30 and 46, as at *B.* thence draw the *Line B. K.* ſo is the *Angle B. K. M.* 100 degrees, 5 minutes, as was required. And after the ſame manner may any *Angle* be laid out moſt *exactly* and *expeditiouſly*, which is of very great uſe where *Inſtruments* cannot be *gotten*, or muſt not be *uſed*.

Of the New Way of Fortifying Places, according to the Sieur Blondel.

This *Author* tells us, That he had made *Fortification* the buſineſs of his *Life*; That he had ſeen all the *Fortified Places* in the *World*; And that he had *diligently* obſerved where their *ſtrength*, and where their *weakneſs* lay; That he had ſerved as *Engineer* in many places as they were *attacqued*, and as they had been *defended*; That he had aſcended from all the *lower*, to all the *higher* Employments in *War*, whereby he has known the difference between *drawing* Lines upon *Paper*, and *marking* them out upon the *Ground*, in the preſence of the *Enemy*; whoſe *Diſcourſe* being very *ingenious* and *brief*, I have tranſlated it into *Engliſh*, as followeth.

In all theſe Occaſions *Experience* has taught me, That the *Art of War* has not found out ſo many ways to *defend* Towns, as to *attacque* them, which made me make it my *buſineſs* for a long time to invent ſome ſort of *Fortification* which ſhould deprive the *Beſiegers* of that advantage of *ſtrength* which they have by reaſon of their great number of *Men*, and great *Guns*, and which ſhould give the *Beſieged* ſpace enough to mount more *Artillery*, and an advantage capable to ſupply the ſmall number of their Men.

But in regard that what I have *thought* upon in this *Particular* is altogether new, I make no *queſtion* but that I ſhall *draw* upon myſelf the *Cenſure* of ſeveral perſons. And it is alſo as *true*, that there is nothing more *dangerous*, than to introduce *new Inventions* contrary to the *received Cuſtoms*, which is the Reaſon that I do not here pretend to give any *Advice* as a certain Rule; they are only my *plain thoughts*, which, however, have ſomthing of *ſure Ground* and *Foundation*, and which may be uſeful, if examined, without *prejudice*.

But to render them the more *intelligible*, we muſt look back to the firſt *Principles* of the *Art*.

The firſt *Rule* therefore of the *Art* is this, that all the parts of the place ought to be *flank'd*.

The ſecond, that the *Line of Defence* ought not to exceed *Muſquet-ſhot*.

The third, that the *whole Fortification*, and particularly that of the *Flanks* ought to be *ſtrong* enough to reſiſt the *Enemies* Cannon.

From

From theſe three *Rules* ſpring the three principal manners of *Fortifying*, called the *Italian*, the *French*, and *Dutch*.

The *Italians*, who were the firſt that began to erect *Fortifications* at the time when *Breaches* were made with *Cannon-ſhot*, among other things would have it ſo, that the Point of their *Baſtions* ſhould neceſſarily contain a *Right Angle*, becauſe they they *thought* their *Bulk* would the better reſiſt the Force of the *Artillery*, and they made their *Demigorges*, and their *Flanks* of the 6th part of the inner ſide of their *Polygon*, and perpendicular to their *Courtain*, contriving *Orillons*, and *high* and *low Places* for the *Defence* of the *Moat*.

The *French*, perceiving that the *Flanks* were eaſily broken down by the *Batteries*, which the *Enemies* were wont to lodge upon the oppoſite *Counterſcarp*, thought at firſt it was the beſt way to ſecure them, by winding them *acroſs* to the Enemy, and making them *perpendicular* to the *Face* of the Enemy. But underſtanding the *weakneſs* of the *oblique Defence*, and that it was not ſufficient that a *Flank* ſhould be cover'd, if it did not alſo itſelf diſcover what the Enemy might do in the *Moat*, they preſently alter'd that *Contrivance*, and made their *Flanks* perpendicular to the *Courtain*, as the *Italians* did, allowing to the *flank'd Angle* the two thirds of that of the *Polygon*.

The *Hollanders* never heeded whether their *flank'd Angle* were acute or no, provided that it were not ſo, that the *Point* could not be eaſily bro-

ken down by the *Cannon-ſhot:* And they made it uſually by adding 15 degrees to the half of the *Angle* of the *Polygon*, and proportioning afterward their *Courtain*, their *Face* and their *Flank*, in ſuch manner that the *Courtain* ſhould be the double of the *Face*, and that the double of the *Flank*. They made it their buſineſs chiefly to allow to their *Face* the moſt that poſſibly they can of the *Flank* in *Courtain*, without *Orillions* or *low Places*, but only a *Fauſſebray*.

This manner of contrivance of ſecond *Flanks* would be very good, if beſides the inconvenience of the *oblique Defence*, the re-entring *Angle* of the *Counterſcarp* did not take away from the *Flank* the ſight of the oppoſite *Face*, when the *Moats* are of a reaſonable breadth. But this defect is ſo ordinary and frequent in *Forts*, the moſt conſiderable which are erected after this manner, that I am ſurpriz'd to find that it has acquir'd ſo great a *Reputation*, in regard it ſeems that the *Flanks* are not built for any uſe, and that the *Faces* are not to be defended but by a *little part* of the *Courtain*.

But though theſe ways have been *invented* and *put* in practice by great Men, and that they have hitherto had the approbation of ſuch as ſtudy the *Defence of Forts*; nevertheleſs the ſmall reſiſtance which the beſt of theſe *Fortifications* have made in the laſt Wars, (and particularly upon the King's march ſome few years ſince into *Flanders*,) has made us believe that the knowledge and skill in *attacquing* was infinitely improv'd above that of *defending* Places, and that ſuppoſing the Courage and Induſtry equal, and all other things proportionable between the *Aſſailants* and *Defendants*, yet the

the condition of the *Beſieger* is much above his that is beſieged.

Monſieur *de Pagan* diſcourſing upon this very Principle, had propos'd a way of *Fortification*, which indeed is infinitely to be preferr'd before the common ways, by making the *Flanks* of a good fair largeneſs perpendicular to the *Line of Defence*, and capable of *three Batteries* one upon another. And the *Model* which appear'd ſome years ſince in *England*, contain'd no more than an eaſie practice of his middle way of *Fortification*.

But, in my Opinion, he has not drawn out the *whole Defence* which the diſpoſition of the place might allow him; And as I am one who is of Opinion, that *Forts* are loſt for want of *Flanks*, whether they be broken down by the *Batteries* of the *Counterſcarps*, or whether they be too ſmall of themſelves, or ſo cloſed up, that they cannot well diſcover the *Faces* of the *Baſtions* which are oppoſed againſt them.

Therefore I thought good to produce a way which extremely augments the *Grandeur* or *Largeneſs* of the *Flanks* and *Demigorges*, ſo as to make ſeveral *Batteries* thereupon, which entirely diſcovers the *Moat*; which deprives the Enemy of the means of making his *Batteries* upon the *Counterſcarp*, which as ſtrongly defends the *Outworks* as the *Moats* of the Body of the Place, and which does not extend the *Line of Defence*.

To this purpoſe I take away a *Right Angle* from that of the *Figure*, and I take the 3d part of the *Remainder*, which I add to 15 degrees to make my diminiſh'd *Angle*, upon which I draw the Sides of

my *Tenaille*, of which I take the half of the one part and the other for the *Faces* of my *Baſtions*. Then having divided the *Exterior Side* into ten equal parts, I take ſeven of them, which I carry back upon the *Sides* of my *Tenaille* to begin at the *Angle* of the *Baſtion* to make my *Lines of Defence*, of which I joyn the *Extremities* by a *Right Line*, which makes my *Courtain*; and from the ſame *Extremities* toward thoſe of the *oppoſite Faces*, I draw the *Lines* of my *Flanks*; And thus my *Tenaille* becomes fortify'd with two *Faces*, two *Flanks*, and a *Courtain*.

By this Contrivance the *Flank'd Angle*, or the *Angle of the Baſtion* in a *Square* is of 60 degrees, of 66 in a *Pentagon*, of 70 in an *Hexagon*; and ſo it augments by little and little in all other *Polygons* to the *Right Line*, where it is of 90 degrees.

The *Flanking Angle*, or the *Angle* of the *Tenaille*, is in the *Square* of 150 degrees, in the *Pentagon* 138. in the *Hexagon* 120. and ſo diminiſhes by little and little in all the other *Polygons* to the *Right Line*, where it is but of 90 degrees.

The diminiſh'd *Angle* is in the *Square* but of 15 degrees, of 21 in a *Pentagon*, of 25 in an *Hexagon*, and it augments by little and little in all the other *Polygons* as far as the *Right Line*, where it is of 45 degrees.

The *Angle* of the *Flank* upon the *Line of Defence* is of 107 degrees, 47 in the *Square*, 100 degrees 41 in a *Pentagon*, 97 degrees 48 in an *Hexagon*, and it diminiſhes by little and little in all the other *Polygons* to the *Right Line*, where it is but of 90 degrees.

The

The *Angle* of the *Flank* upon the *Courtain*, is of 122 degrees, 47 to the *Square*; 123. 11 to the *Pentagon*; 123. 48 to the *Hexagon*: And it augments by little and little in all the other *Polygons* to the *Right Line*, where it is of 135 degrees.

And becauſe I am perſuaded that the *Line of Defence* ought never to be larger than 140 *Toiſe*, nor leſs than 120, in ſuch *Forts* as are called *Royal*, I have for that Reaſon made two Suppoſitions, which I call two Ways; of which the firſt, which is the grand one, makes its *Exterior Side* of 200 *Toiſe* in all *Polygons*, which allows through the whole 140 *Toiſe* for the *Line of Defence*. And the ſecond Way, which is the leſſer, makes throughout the ſame *Exterior Side* of 170 *Toiſe*, which gives little leſs than 120 *Toiſe* for the *Line of Defence*, within which *Limits* I include all that may be fortify'd; for that a longer Extent of the *Exterior Side* renders the *Defence* unprofitable, by reaſon of the too great diſtance of the *Flanks*; and a leſſer Extent diminiſhes the length of the *Flanks*, and augments to no purpoſe the number of *Baſtions*, and the *Expence*.

In the *Great Way*, where the *Line of Defence* is 140 *Toiſe*, and the *Exterior Side* 200.

The *Flank* is to the *Square* 27 *Toiſe*, 36¼ to the *Pentagon*; 42½ to the *Hexagon*; and it augments proportionally to the *Right Line*, where it is of 70½.

The *Demigorge* is to the *Square* 28¼ *Toiſe*; 35½ to the *Pentagon*; 39 to the *Hexagon*; And it augments proportionally to the *Right Line*, where it is of 70½.

The *Courtain* to the *Square* is of 70½ *Toiſe*, 60½ to the *Pentagon*, and 54 to the *Hexagon*; And it diminiſhes by little and little in all the other *Polygons*, till it come to nothing at the *Right Line*.

In the *Leſſer Way*, where the *Line of Defence* is not above 120 *Toiſe*, and the *Exterior Side* 170,

The *Flank* in a *Square* is 23 *Toiſe*, 31 in a *Pentagon*; 35 in an *Hexagon*; And it augments by little and little in all the other *Polygons*, till you come to the *Right Line*, where it is 60 *Toiſe*.

The *Demigorge* in the *Square* is 24½ *Toiſe*, 29 in the *Pentagon*; 32 in the *Hexagon*; And it augments by little and little in all the other *Polygons* as far as the *Right Line*, where it is of 60 *Toiſe*.

The *Courtain* is to the *Square* 60 *Toiſe*; 52 in the *Pentagon*; 46 in the *Hexagon*; And it diminiſhes by little and little in all the other *Polygons*, until it come to nothing at the *Right Line*.

By which, in the firſt place you may ſee that this Way is not much different from the *Dutch* Way, in reference to the *flanked Angle*, which is the ſame as well in the one as the other to the *Square*, and which differs not in the other *Figures*, only in this, that the enlarging that *Angle* goes a little ſwifter in the *Dutch* Way, where it is ſtrait to the *Dodecagon*, than in this where it is no more than 80 degrees, and does not become right, but at the *Baſtion* upon the *Right Line*. And theſe differences are of ſo ſmall conſequence as to the *ſtrength* or

weak-

weakneſs of the *Point* of the *Baſtion*, that it is not worth the while to make any ſtir about them; But, on the other ſide, they enlarge in ſuch a manner the neceſſary parts of the *Fortification*, that we had juſt cauſe to make uſe of this manner, rather than of any other: Which may be eaſily underſtood by the difference of its *Parts*, which is much larger in the *Flanks* and *Demigorges*, which are the *Parts* that augment the *Defence*, than in the *Faces* which diminiſh it; That of the *Flanks* being 42 *Toiſe* and an half between the *Square* and the *Right Line* in the large manner, and 37 *Toiſe* in the leſſer manner; That of the *Demigorges* of 71 *Toiſe* and an half in the large manner, and 60½ in the leſſer manner; whereas on the contrary the difference of the *Faces* is no more than 19 *Toiſe* in the large manner, and 16 *Toiſe* in the leſſer.

As for what may be objected, That the *acute Angles* of the *Point* of the *Baſtions* diminiſh their Capaciouſneſs, it is of little importance; ſince the difference of the Surface of a *Baſtion* to a *Right Angle*, and of another to an *Angle* of 60 degrees, the *Faces* being equal as well in the one as the other, is no more than an 8th part, which comes inſenſibly to 70 degrees, and ſomwhat more.

My *Flanks* are not quite throughout *perpendicular* to the *Line of Defence*, as in the *Manners* of Monſieur *de Pagan*, for he makes there an *Angle* ſomwhat obtuſe upon the firſt *Polygons*, and the difference of the *Perpendicular* is no more than of 17 degrees, 47 to the *Square*; 10 degrees, 41 to the *Pentagon*; and 7 degrees, 48 to the *Hexagon*, and

and what is above is inſenſible; ſo that it is ſo ſmall a thing, that it gives no conſiderable *Obliquity* to the *Defence*. However this difference enlarges in ſuch a manner my *Demigorges*, then I find place in the *Square* for three *Batteries*, where I could hardly raiſe two if the *Angle* were always *Right*.

Here I make uſe of all the Arguments which Monſieur *de Pagan* brings againſt thoſe, who fear a too great expoſing of the *Flanks* to the *Batteries*, which the *Enemies* raiſe upon the *Counterſcarps*, with this difference only, that he mounts, for the moſt part, not above 12 or 13 pieces in his *Flanks* to oppoſe thoſe of the Enemy, when as in certain *Forts* I could oppoſe againſt the *Beſiegers* in my *Flanks* an hundred or ſixſcore Pieces, and never leſs than twenty, or five and twenty in the ſmalleſt *Forts*.

My *Demigorges* are large enough for three *Batteries* one above another, one above, a ſecond in the middle, and another below in all the *Polygons*: Nay, in the *Hexagon*, and *Forts* of more *Angles*, there is room enough to raiſe *Cavaliers* upon the *linings* of the *Flanks*, making uſe for that purpoſe of the *Earth* thrown up out of the *Moats*.

I do not take above 8 or 10 *Toiſe* in the *Flank* at the *Angle* of the *Shoulder*, to ſerve me for a kind of *Orillion*, and I employ all the reſt in the *cover'd Flank* for *Batteries*, or to lodge *Small-ſhot*; ſo that I have 18 or 20 *Toiſe* of *cover'd Flank* in the *Square* for every *Battery*, that is to ſay, for nine

nine or ten pieces each, and for thirty or two and thirty for the three.

In a *Pentagon*, 26 *Toiſe* of length of *cover'd Flank*, that is to ſay, for 13 or 14 pieces for each *Battery*, and 40 or 45 pieces for the three.

In an *Hexagon*, 32 or 33 *Toiſe* of *Flank cover'd*, that is to ſay, 16 or 17 pieces for each *Battery*, and eight and forty or fifty for the three; beſide 18 pieces for the *Cavalier*, which makes ſixty eight or ſeventy pieces for the defence of each *Flank*.

And ſo in others, enlarging to the *Right Line*, where I have 60 or 61 *Toiſe* of length in *Flank Covert*, which cannot afford room for thirty, or two and thirty pieces in each *Battery*, and above fourſcore and ten pieces for the three, and about an hundred or ſixſcore pieces for the whole *Flank*, comprehending the *Cavalier*.

In a *Pentagon*, or a *Figure* of more *Angles*, I draw back my loweſt *Battery* of the breadth of five or ſix *Toiſe* within the *Demigorge*, to the end it may be the better cover'd by the advance of the *Shoulder*, which ſerves it inſtead of a *ſquare Orillion*. And this drawing back ſerves me to extend my *Courtains* to the *Baſtions* of *Polygons* of ſeveral ſides, and to allow one to thoſe that are upon the *Right Line*, to which I would for the ſame reaſon retire my *Flanks* within ſide, about 10 or 12 *Toiſe* on each ſide, to the end I might have 14 or 15 *Toiſe* of *Courtain*.

My

My inner *Batteries* enlarge themſelves within-ſide, becauſe they are contained between two *Lines*, of which the one is that of the *Defence* extended, and the other runs within-ſide from the point of the *Baſtion* oppos'd, and paſſes through the corner of the *Orillion*, which by that means gives me room for five or ſix pieces, which lie conceal'd under the *Shoulder* of the *Orillion*, which the *Italians* call the *Traytor*, and which cannot be ſeen by the *Counterſcarp*, though they diſcover the whole face of the *Baſtion* oppos'd, and the inſide of the *Breach* that may be made therein. It is alſo impoſſible to diſmount thoſe *Batteries* by *Side-Shots*, by reaſon of the *length* of the *Flank*.

I allow for the Plane of the *Batteries* of the *Flank*, from 9 to 12 Foot of *height* the one above the other; That is to ſay, that the Plane of the loweſt *Battery* ſhall not be above the *Moat* for the *leaſt heighth* above 9 Foot, and for the *higheſt heighth* not exceeding 12. To the *middle Battery*, for the *leaſt height* 18 Foot, and at moſt not above 24. And for the top of the *Rampart* of the *Baſtion*, which is the ſame with the Plane of the uppermoſt *Battery*, not leſs than 27 Foot, nor more than 36. The *Cavalier* ought to be rais'd above the Plane of the *Baſtion* to the ſame *heighth* of from 9 to 12 Foot, not comprehending that of its *Parapet*.

My *Parapets* are 3 *Toiſe* in *breadth*, from 9 to 10 Foot in *heighth* above the loweſt *Batteries*, from 6 to 7 Foot above the *middlemoſt* with *firing holes* both in the one and the other, and 3 Foot and an half

half in reſpect of the other *Batteries*. The *breadth* of the *Platforms* to the *middlemoſt Batteries* and *lowermoſt*, is no more than from 4 to 5 *Toiſes* without the *Parapet*.

The diſpoſal of my *Baſtions* gives me alſo this advantage, that the *oppoſite Faces* ſee one another, and defend one another athwart a *Defence*, thruſting itſelf far in, and which diſcovers the *Back* of the *Breaches*.

I make a *Halfmoon* or *Counterguard* at the point of each *Baſtion*, and parallel to its *Faces* of ſolid *Maſon's-Work* without *Earth*, and countermin'd quite thorough, 3 *Toiſe* and an half, or 4 *Toiſe* broad at moſt, that is to ſay, of 6 or 8 Foot of *Parapet*, and 12 or 15 Foot of *Rampart*.

This *Counterguard* ſerves me principally to deprive the *Counterſcarp* of the ſight of the *Batteries* of the *oppoſed Flank*, and its want of *thickneſs*, is to hinder the *Enemy* from planting his *Cannon* upon it in caſe of forcing it; which is much better, than to make a great *Traverſe* in the *Moat*, by continuing the *Capital Line* of each *Baſtion*, becauſe this does not hinder the liberty of the *Moat*, works the ſame effect as the *Traverſe* for the ſecurity of its *Flanks*, and ſerves of itſelf to defend itſelf.

I raiſe another *Halfmoon* in the midſt of the *Courtain*, which covers entirely the *Shoulders* or *Orillions* of the *Baſtions*. And for the *Defence* of the *Moat*, I take in the *Face* of the *Baſtion* ſo much

much room as may ſee it, where I make a *low Battery* of five or ſix pieces, and another behind that within-ſide about the *height* of the *Parapet* of the *Fort*. The *Plane* of the *low Battery* ſhall be level with that of the *middlemoſt* of the *Flank*, that is to ſay, from 18 to 24 Foot high above the bottom of the *Moat*. And in regard its *Parapet* is 6 or 7 Foot high, the heighth without-ſide ſhall be from 25 to 32 Foot high; which ſuffices to remove all fear, leſt the *Face* of the *Baſtion* ſhould be too much weakned in that part.

This *Halfmoon* ſerves me alſo to defend the *Moat* of the *Counter-guard*, and I take in its *Face* all that can expoſe it to view, where I continue two *Batteries*, the one *above*, the other *below*, in the ſame manner as in that of the *Baſtions*, I allow for *Platform* to this *Halfmoon* no more than is neceſſary for the *Recoyle* of the *Guns* of the *Batteries*, and I leave the remainder of the *inſide* all void, for the more eaſie making *Countermines* in the *Rampart*, and to take away from the Enemy the means of *lodging* upon it after they have forced it.

In the re-entring *Angles* of the *Counterſcarp* between the *Counterguards* and the *Halfmoon*, I place little *Moons* of a reaſonable of *ſolid Maſons work*, and like to that of the *Counterguards* themſelves; which I do, to prevent the *Flanks* of my *Baſtions* from being ſeen *athwart* any part of the *Field*.

And becauſe it is in this *Moat* that the greateſt

Defence

Defence ought to be made, I make it here the *whole breadth* of my *Flank*, for the lodging the *Counter-guards*, and their *Moat* therein, proportioning the largeneſs both of the one and the other, in ſuch a manner, that there may remain ſufficient for the *great Moat*. And to the end it may be ſeen by all the *Flanks*, I draw *Lines* from the *Angles* of the *Shoulder* to the Point of the *oppoſite Baſtions*, which determine the re-entring *Angles* of my *Half-moons*, ſo that they are no Impediment to the *Defence*.

I alſo make a *Cunett* in my great *Moat*, which I cauſe to run round about of the breadth of from 7 to 8 *Toiſe*, diſtant 5 or 6 *Toiſe* from the *Counterſcarp*, that it may not be eaſie for the Enemy to fill it with the hole of their deſcent into the *Dike*, leaving the reſt at the Foot of the *Moat* for the making of *Retrenchments* and *Lodgings*, and to diſpute the paſſage with the *Enemy*. It alſo ſerves me to guard me from any *Aſſault* that may be fear'd on the ſide of the *low Flanks*, which ſeem to be inacceſſible. And for the more ſecurity, you need no more than continue the *Wall* that ſurrounds the place to the thickneſs of two Foot through the whole *Flank*, and as high as the reſt, and this *Wall* may be beaten down as occaſion requires.

Moreover, I ſee nothing that ſhould hinder me from making another narrower *Cunett* in the *Moats* of the *Outworks*, if they are 10 or 12 *Toiſes* broad, eſpecially in thoſe parts where they have contrived the *low Batteries* in the *Faces* of the *Halfmoons*. I alſo raiſe *Coffres* and *Caponniers* in all the *jutting forth*

forth and *re-entring Angles* of the *Cunetts* to defend the *Faces*, and to be near the *Paſſages* which the *Enemy* may attempt under-ground.

I leave beyond the *Counterſcarp* of the *Works* without a *Coridor* of from 7 to 8 *Toiſe* large cover'd with its *Bankets* and its *Eſplanade*, or *level'd way*, allowing, if you pleaſe, *juttings out without-ſide*, to the re-entring *Angles* of the *Counterſcarp*, for the taking up of *Ground*, and contriving the more ſpacious places of *Arms*.

Thus I do not ſee any part of my *Fortification* which may not be ſeen by at leaſt 3 or 4 others: Nor do I know that hitherto there has been propoſed any other manner which allows ſo much room for the Fire of the *Defence*, and gives ſo many *Impediments* to that of the *Aſſailants*.

Which, in my Opinion, is all that can be deſir'd in a good *Engeneer*, to whom it is not juſt to impute what ſhall fall out *unfortunate* in a *Siege*, through the ignorance or death of the *Commander*, through the ſmall Number or Cowardice of the *Soldiers*, through *Mutiny*, or *Want of Victuals*, or *Ammunition*, or other *Misfortunes*, which are uſually the *Loſs of Places*.

If you think it *fitting* to defend Yourſelf againſt *Mines* and *Blowings up*, make uſe of what Mr. *Pagan* propoſes in his *Baſtions*, which is to allow a little more breadth to the *Faces* of the *Baſtions*, and there to make ſecond *Ramparts* within-ſide ſeparated from the firſt by a *Moat*, which cannot but be a very good way. I could

I could alſo make it appear, that this *Fortification* might be infinitely augmented by the *Multiplication* of the *Outworks*, and by ſeveral *Advantages* which it is capable to receive within-ſide; That in ſuch places, whoſe *Gorges* are very wide, you may retrench the length of their *Faces* towards the *Shoulders*, and by this means conſiderably extend the *Flanks*, which, upon the *Right Line*, without altering any thing of the other parts, might be enlarg'd to that degree, as to contain above 200 pieces of *Cannon* for the defence of the *Moat* which is oppoſite to them. That this *Fortification* alſo might be applied to all ſorts of *Figures*, *Regular* or *Irregular*. That ſuch Places already fortify'd, according to other ways, might be eaſily reduced to this, without changing the *Faces* of the *Baſtions*, or the *Works* without, provided always that they have a ſecond *Flank*, or a *Courtain*. A thouſand other things could I make appear of this Nature, which I omit, as having propos'd to myſelf in this *Diſcourſe*, to give the *Explication* of my *Way* and *Manner* the moſt *plainly* and *ſuccinctly* that poſſibly I could.

Many Men will be ready to oppoſe againſt this *Invention*, many *Difficulties*, as the Vaſtneſs of the *Expence*, the Number of *Artillery* and *Cannoneers*, the Largeneſs of the *Moats*, the great quantity of *Earth* which is requiſite to be taken out, and the difference between this *Fortification* and all others that have been in uſe: They will alſo object the neceſſity of demoliſhing the *ancient Works*, and many other things of this Nature.

But my deſign is not here to combat theſe contraryOpinions, the Queſtion is only to know,

whether this manner of *Fortification* be better than any of the other? To which if any one ſhall ſay, That it is none of my Invention, let him do me the kindneſs to ſhew me any former Examples. The new *Fortification* of *Mayence* is the only *Fortification* that ſeems to reſemble mine, but when you have diligently examin'd it, you will find them to be two different things.

I have added to this Diſcourſe ſome deſigns, the better to facilitate the underſtanding of what I have ſaid: Of which the firſt Draught is, to teach you the practice upon all ſorts of Angles of *Polygons* given. The ſecond is, to ſhew you how eaſie it is to reduce all places already fortify'd to this method, provided they have a ſecond Flank without any alteration either of the Faces of the *Baſtions*, in the *Moats*, or the Works without. The third is part of four ſeveral *Polygons* fortify'd according to this method, wherein the points of the *Fortification* are exactly ſet down. The laſt is the *Plane* of the City of *Dunkirk*, upon which I have put another according to my method, that by comparing the one with the other, you may the more eaſily apprehend which is the beſt. *Plate* xxvii, xxviii, xxix.

The New Manner of FORTIFICATION, *By the Sieur* Blondel. *Plate* xxviii. *Fig.* 1, 2.

Suppoſe you were to fortifie the *Angle Q. A. B.* of which the *Sides A. Q.* and *A. B.* are equal. From the *Centre A*, at whatſoever diſtance it be, as *A. R.* let the Circle *R. 2. Z.* be drawn, cutting the Sides at *R.* and *Z.* wherein from the Point *R.* draw

Plate XXVIII.

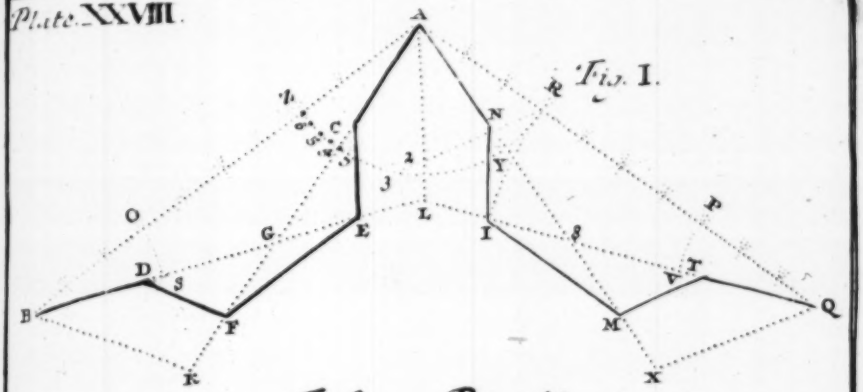


Fig. I.

First Draught

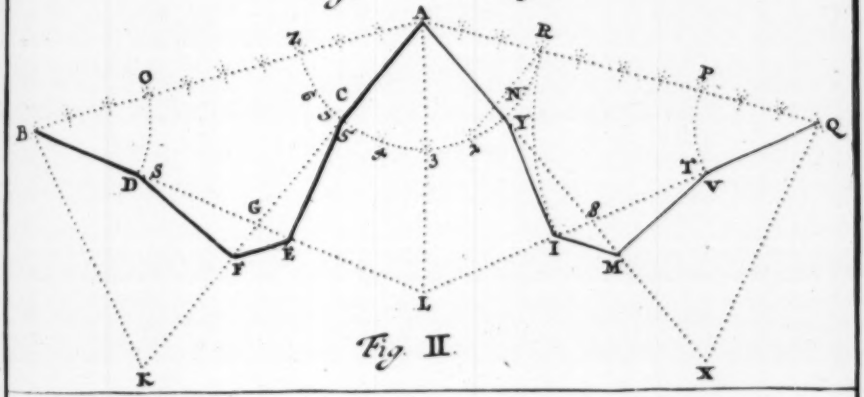


Fig. II.

Second Draught

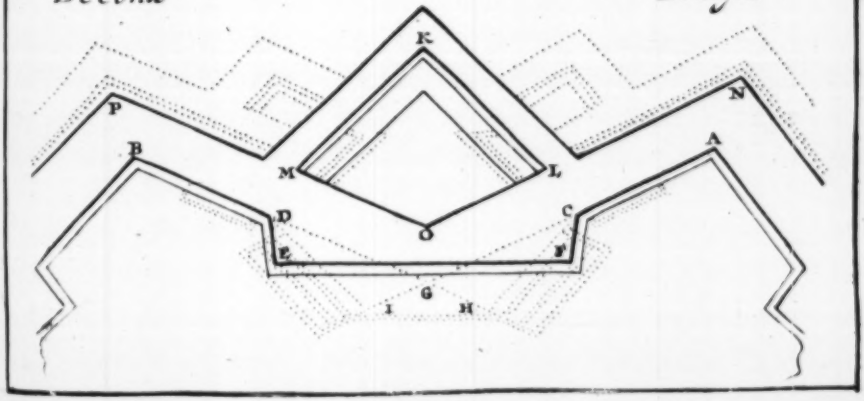
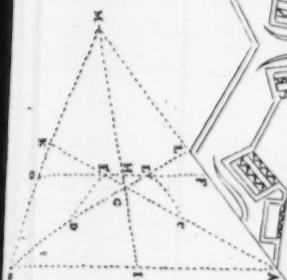


Plate XXIX

Draught 3

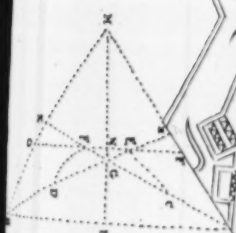
Heptagone

Pentagone



Hexagone

Square



R. draw the Right Line *R.* 2. equal to the *Radius A. R.* to the end that the *Arch R.* 2. may be of 60 degrees: To the half of which let the *Arch* 2. 4. be made equal, which will be done by the means of 30 degrees, and the entire *Arch R.* 4. of 90 degrees. And then dividing the *Arch* 2. 4. equally into two parts at the Point 3. the *Arch* 3, 4. will be of 15 degrees. Then the *Arch* 4 *Z.* (which is the Remainder of the *Angle* propos'd, from which you have taken one *Right Angle*) may be divided into 3 equal parts at the *Points* 5. and 6. And taking the *Arch* 3, 5. (which is made of the *Arch* 3, 4. of 15 degrees, and the *Arch* 4, 5. which is the 3d part of the *Arch* 4 *Z.* carry it back from the *Points R.* and *Z.* upon the Circumference of the *Circle* to the *Points Y.* and 7. and from the *Points P.* and *O.* to the *Points V.* and *S.* ſo that every one of the *Arches R. Y. Z.* 7. *P. V. O. S.* may be equal to the *Arch* 3. 5. At length through the Points *Y.* and 7. from the Point *A.* and through *V.* and *S.* from the *Points Q.* and *B.* you muſt draw the *Right Lines A. Y. X. Q. V. L. A.* 7. *K. B. S. L.* which cutting themſelves reſpectively at the *Points* 8. and *G.* will make the *Tenailles A.* 8. *Q. A. G. B.* every one of the *Sides* of which muſt be equally cut into two parts, at the *Points N. T. C. D.* which will *terminate* the length of the *Faces* of the *Baſtions A. N. Q. T. A. C. B. D.* After which you need no more than divide one of the *Sides* of the *Angle*, as *A. Q.* into two equal parts, and take ſeven of them as from the Point *Q.* to *R.* which you are to bring back upon the prolong'd *Sides* of the *Tenaille*, as from the *Point Q.* to *F.* from *A.* to *M.* and *F.* and from *B.* to *E.* to have the

length of the Lines of Defence *A. M. A. F. Q. F. B. E.* and laſt of all join the Points *I. M. F. E.* and *I. N. M. T. E. C. F. D.* to have by that means the Right Lines *I. M. F. E.* for *Courtains*. The Right Lines *F. N. M. T. E. C. F. D.* for the Flanks; and the Right Lines *A. C. A. N. Q. T. B. D.* for the Faces of the Baſtions.

How to apply the new manner of Fortification of Places *which have a ſecond Flank, without altering any thing either in the Faces of the* Baſtions, *in the* Moats, *or* Outworks. *Plate* xxviii. *Fig.* 3.

Suppoſe a *Tenaille* fortify'd after the *Dutch* manner, of which the Faces of the Baſtions are *A. C. B. D.* the Flanks *C. F. D. E.* and the Courtain *F. E.* the Counterſcarp *N. O. P.* and the *Halfmoon K. L. O. M.* where the Point *O*, which makes the re-entring Angle of the Counterſcarp, takes away from the Right Flank the ſight of the Face of the Baſtion, which it ought to defend according to the moſt ordinary and worſt way of *Fortification*. To reduce it to the new way, you have no more to do than to continue the Lines of the Faces of the Baſtions beyond the flanking Angle *G.* as *A. C. F.* and *B. D. H.* then from the Point *A.* upon *B. H.* and from the Point *B.* upon *A. F.* to draw the Perpendiculars *C. H. D. F.* which will be the Flanks, and *H. F.* the Courtain of the new *Fortification*; wherein there is nothing alter'd neither as to the *Faces*, the *Moat*, nor the *Outworks*. The Lines of the Points mark out the Detaile of the Parts, as well for the *Batteries* of the *Flanks*, the *Baſtions*, and the *Halfmoons*, as for the *Counterguards* and *Lunettes*.

The

The making of Ramparts, Parapets, Ports and Moats.
Plate XXIV.

The *Rampart* is to be deſign'd upon a piece of Paper, with proper Figures. Take then with your Compaſſes the half of the *Demigorge A. B.* and if you intend to repreſent upon the *Rampart* the *Parapets*, and *Little Banks*, then it is requiſite that you make *B. K.* the length of the *Flank*, to the end you may determine in the inſide of the Figure, the *Rampart* by the Line *F. G.* parallel to the *Polygon A. S.* which is done after this manner:

Place your Ruler upon the ſide of the *Polygon A. S.* and then your Compaſſes being open, with one Leg draw along by the Ruler, and with the other Line mark *F. G.* which is to be the *Rampart*, which being continued quite through the inſide, the Figure will give the *Baſis*, or Breadth requir'd of the Foot of the *Rampart*, which upon the Ground will be from 12 to 15 Fathom.

For the *Parapet I. L.* we take with the Compaſs the 15th part of the *Flank*, to make within ſide of the place a Parallel to the *Faces*, *Flanks*, and *Courtains*. Upon the Ground it will take up in breadth from three to four Fathom.

The *Little Bank* is alſo made within ſide of the Place parallel, and as near as may be to the *Parapet*. The Gates or Ports are mark'd in the middle of the *Courtains*, from about 8 to 10 Feet in Breadth, and a wooden Bridge over the Ditch,

with Gates and Draw-Bridges in ſeveral parts thereof.

For the *Moat*, the Lines being drawn from the Centre, being prolong'd beyond the *Courtains* and the *Baſtions*, we take the breadth of the *Flank C. O.* then from the Point *M.* or flanqued Angle, make the Arch *N.* drawing from *O.* the ſhoulder of the oppoſite *Baſtion*, the Line *O. R.* through the top of the Arch *N.* obſerving that this Line *O. R.* does cut the Capital Line prolong'd to the Point *S.* and the Line which paſſes through the middle of the *Courtain* at the Point *P.* then carry on the diſtance of the middle of the *Courtain T. P.* to the middle of all the other *Courtains* in *V.* the diſtance of the Capital *M. Q.* prolong'd, beyond all the Capitals in *Z.* Then laſtly, join *V. Z.* and ſo you ſhall have the *Moat* and the *Counterſcarp Z. P. S. V.* &c.

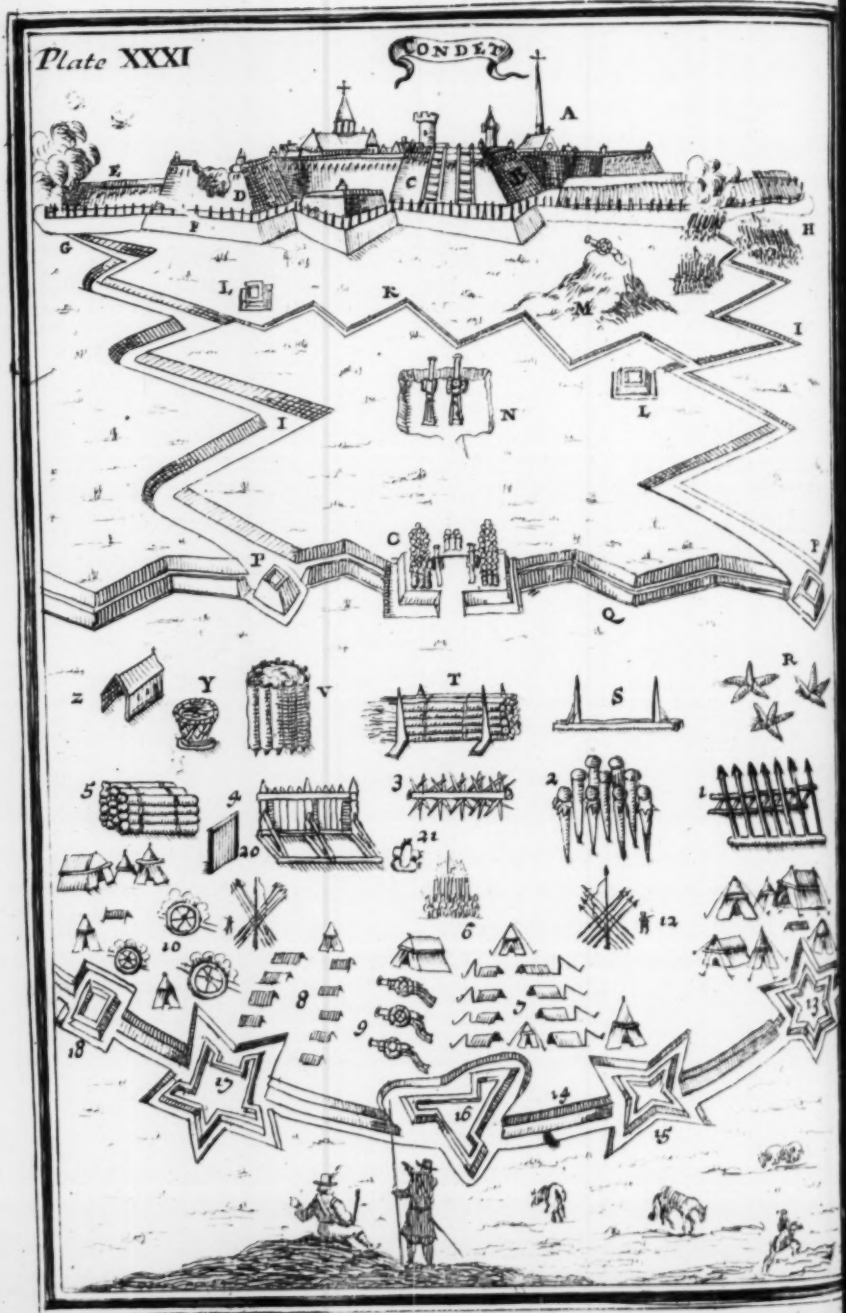
OBSERVATION.

The meaſures which I here ſet down, are bigger than they ought to be, to the end you may the better diſcern the *Ramparts*, *Parapets*, *Little Banks* and *Moats*. But when you would mark them out upon the Ground, you may take their juſt meaſures upon the Outlines of the Figure, which will allow, as here, the *Rampart* to be 12 Fathom broad, the *Parapet* 18 Foot, the *Little Bank* three Foot, and the *Moat* 23 Fathom.

This *Section* ſhould have followed in *Page 69.* after *Plate* xi.

CHAP.

Plate XXXI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CHAP. XII.

The Offenſive Part of Fortification, ſhews how to beſiege and take a fortified Place, and conſiſts chiefly in theſe following Parts. Plate xxxi.

1. IN forming and ordering the Camp and Quarters, alſo in the defence and diviſion of the Camp.

2. In the inward and outward Works of the Camp, which are *Forts*, *Redoubts*, *Stars*, *Trenches*, &c.

3. In the *Batteries*, *Approaches*, *Saps*, *Galleries*, *Mines*, *Breaches*, *Aſſaults*, &c. All which are repreſented in Plate *xxxi.*

A. is the *Profile* or *Senographie* of a Place or Town.
B. is the *Freize* or ſeveral pieces of *Wood* faſtned under the *Parapet.*
C. is the *Ladders* or *Eſcalade.*
D. is the *Breach.*
E. is the *Mine.*
F. is the *Paliſadaes.*
G. is the *Sap.*
H. the *Attaque.*
I. is the *Trenches* of the *Approaches.*
K. is the Line of Communication, *ou Boyaux.*

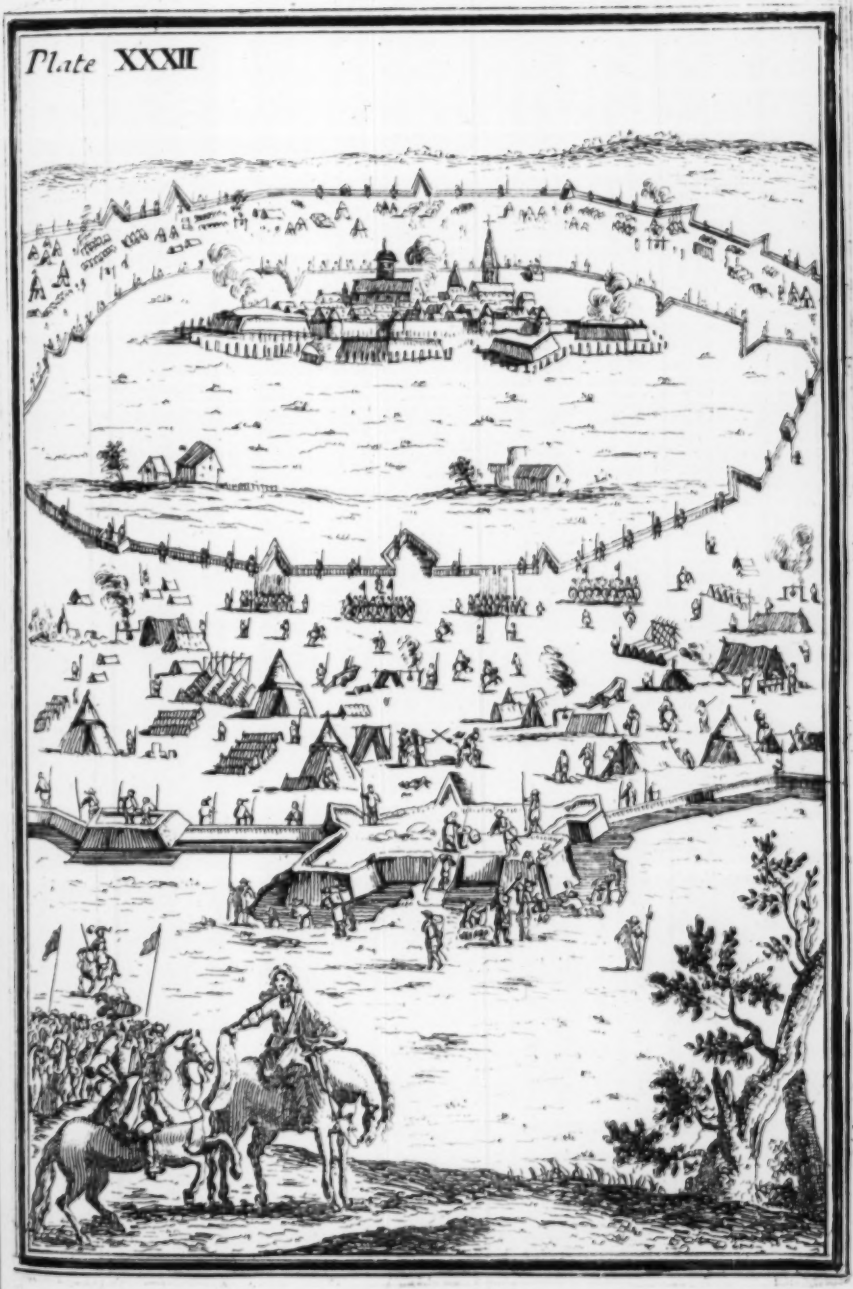
L. is a *Redoubt* for the Defence and Conſervation of the *Approaches.*
M. is a high *Battery.*
N. is a *Battery* made up of *Earth.*
O. is a *Battery* of *Gabions P.*
Q. is the *Line of Contravallation.*
R. is *Chaus-Traps*, *Crow-Feet*, or *Calthrops.*
S. Chandileers.
T. Fagots in a *Chandileer.*
V. Gabions.
Y. Corbeiles, or *Baskets of Earth.*
Z. Gallery.

1. A *Fence* made of *Paliſadoes.* 2. *Piles* or *Paliſadoes.* 3. *Horſe de Freeze*, or *Turnpikes.* 4. *Barricade.* 5. *Sauciſſon.* 6. The *Camp.* 7. The *Barraques* for the *Cavallerie.* 8. *Hutts* for the *Infantry.* 9. The *Park* of *Artillery.* 10. The *Tents* for the *Proviſions* and *Stores.* 11. *Place* of the *Arms.* 12. The *Corps de Gard.* 13. The *Quarter* for the *King* or *General.* 14. The *Line* of *Circumvallation.* 15. is an *Eſtoile.* 16. a *Demi-Baſtion.* 17. a *Cemiſe.* 18. a *Redoubt.* 19. a *Vedetter*, or *Horſe Sentinel.* 20. *Mantelets.* 21. *Sacks* of *Earth.*

Of Beſieging Towns.

There are ten Acts proper for a *Siege:* 1. *Blocking up the Town.* 2. *The diſpoſing of the Camp or Quarters.* 3. *Circumvallation and Contravallation.* 4. *The opening of the Trenches.* 5. *The carrying on of the Lines of Approaches.* 6. *The Batteries for great Guns.* 7. *The Line of Communication.* 8. *The Sap.* 9. *The Gallery.* *And* 10. *the Mine.* All which I ſhall briefly, but diſtinctly explain. 1. *Block-*

Plate XXXII



1. *Blocking up a Town*, is when the *Beſiegers* take care to ſtop all ways and paſſages, and all Intelligence that may be ſent into or out of the *Town* or *Fort* that is attacked.

Of the Camp *and* Quarters.

2. As ſoon as the place is blocked up, and all the *Army*, *Baggage*, *Proviſions of War*, and the *Artillery* are arrived, then the *Camp* is formed out. And here is to be well conſidered the condition and ſituation of the place, how the *Quarters* as well for the *Cavalry* as *Infantry* may be diſtributed, and how beſt ſecured with ſufficient *Trenches*, *Batteries*, *Redoubts*, and other Works neceſſary; more particularly muſt be conſidered theſe Circumſtances.

1. *Hills* and other high places near a *Camp*, which muſt be ſecured by ſtrong works, or by a detachment of *Soldiers*, or elſe altogether avoided.

2. The *Camp* muſt be above *Cannon-ſhot* from the Town, that ſo the Enemies Guns may do it no damage.

3. If the *Camp* muſt be formed in a low place, great care muſt be taken, and it muſt be well viewed, whether it may not be overflowed and drowned.

4. If it happens that the *Camp* muſt be near a *Wood*, then the *Wood* muſt be included in the *Trenches*, or elſe deſtroyed and burnt up.

5. That if the place ſtands upon a *River*, there muſt be a detachement made of one part of the Army to take its Quarters on the other ſide with Bridges of *Communication* well fortified.

6. That

6. That all *Ports* and *Paſſages* which lead to or from the *Camp*, muſt be well fortified, and ſufficiently ſecured and guarded.

Of the Lines of Contravallation and Circumvallation.
Plate xxxiii.

After the *Camp* is formed, the next thing is to chuſe a fit place to begin the *Line of Contravallation*, called, *Breaking of Ground*, which is to be choſen beyond *Muſquet* or *Falcon-ſhot* from the Town. This *Line*, if the Gariſon be ſtrong, and well ſtored with Men, is carried round about the Town to keep them in, and hinder the Sallies from hurting the *Beſiegers*; And if the Enemy have Armies near that may endeavor to raiſe the Siege before the Town can be taken, then there muſt be made another Line further into the *Campagne*, which is called, *The Line of Circumvallation*. The better to perform this, the *Ingineers* ſhall go round the place, and well obſerve the Ground by which they are to draw the Line, taking a Draught of the circumjacent Ground, obſerving all the *Hills*, *Heights*, *Vallies*, *Rivers*, *Churches*, and whatſoever may ſerve for Lodgings as well for *Horſe* as *Foot*, or whatſoever may ſerve for places of *Covert*. The *Ingineers* having preſented the Draught to the General, and having concluded which way the *Line of Circumvallation* is to be made, it muſt be marked out with *Piquets* and *Chords*. The Breadth about 10 or 12 Foot, and 4, 5, or 6 Foot deep. Upon this Line, within Mulquet-ſhot, or 750 Foot one from another, are to be placed *Redoubts*, *Long Squares*, with *Tenailles*, *Triangles*, *Ravelins*, *Half-Moons*, *Half-Baſtions*, *Star-Works*, *Field-Skonces*, and other Forts

Tabula XXXIII

Forts with *Ramparts*, whoſe *Baſis* may be ſome 8 or 10 Foot thick. The interior height of the *Parapet* 6 Foot, the exterior 5 Foot. The *Banquet* 3 Foot broad, and 1½ high. Theſe Works indeed are various, and are made according to the Circumſtances of the Place, the Strength of the Enemy, and Danger of the Army.

This *Line of Circumvallation* is to be carried round the *Camp*, encloſing Ground enough for all the *Army* to lodge in; And the *Quarters* of the General, and other great Commanders, are to be placed round about, ſo as they may conveniently relieve each other. And theſe *Lines of Contravallation and Circumvallation*, with their ſeveral aforeſaid Works, being, by the *Ingineer* deſigned and marked out in fit diſtances, every Regiment ſhall work at them in their reſpective Quarters.

Of opening the Trenches.

The place for opening of the *Trenches*, that is, the beginning of the *Lines of Approaches* appointed out, which may be about 1000 or 12000 Foot from the Town. There ought firſt to be built a *Redoubt* or *Battery* of Guns well flanked and defended, to keep or divert the *Enemy* from firing into the *Trenches*, which Line is carried on obliquely, ſo that no *Shot* can be made out of any work of the Town that may ſcour the *Trenches*, with 3 or 4 Turnings you may approach to the *Counterſcarp*, *Bank* or *Glacis*, at the end of each Turning there muſt be a *Redoubt* built for *Guards*, the width of theſe *Trenches* may be 12 or 14 Foot at the

the top, the depth 4 Foot, ſo that the *Depth* and *Bank* made of the *Earth* thrown out, may be a good and ſafe *Covert* for the Soldiers, and may be 6 or 8 Foot at the bottom, with 2 or 3 Steps to get up to the *Breaſtwork*, but deeper and wider as you come nearer to the Town: But if the Ground be *Rocky* or *Marſhy* with Bogs, then there muſt be provided abundance of *Hurdles*, *Babions*, or *Cannon Baskets* and *Bavins*, to make great *Eſpaulments* well flanked, to cover the *Soldiers* from the Enemies Cannon. The *Regiments* which are to open the *Trenches*, and beat back the *Sallies* of the Enemies, make their *Detachements* before they draw out of their *Camps*, and provide the number of *Labourers* that the *Ingineers* have requir'd, with *Officers* to lead them. As ſoon as the day ends, the *Soldiers* commanded to work begin to dig and caſt up *Earth*, and others bring *Fagots* and other Neceſſaries; and thoſe that are appointed for Defence of the *Works*, lay themſelves on their *Bellies* ſome paces beyond the *Counterſcarp*, and as ſoon as Day breaks, that Officer commands all to draw back into the *Trenches*.

Of the carrying on the Lines of Approaches *and* Batteries.

1. The *Ingineers* muſt be ſure to be provided with *Piles* or *Paliſadoes* made of Wood, about 3 Inches, or little leſs, in *Diameter* 5 or 6 Foot high, wrought round, plated or ſhod with *Iron* at the *Points*, and having 2 or 3 great *Iron Nails* driven through them towards the *Head* 8 or 9 Inches long, as *Fig.* I. M. N. *Plate* xxxi.

2. With

2. With *Turn-pikes*, or *Spars* of 12 or 14 Foot long, and about 6 Inches *Diameter*, having 6 Sides bored with Holes one right under another, on each ſide about 6 Inches diſtant one from the other; the *Pickets* that are driven into the Holes are 5 or 6 Foot long, pointed with *Iron* at both ends, and well faſtned into the Holes. Theſe are of great uſe to ſtop the Enemy in the *Breaches*.

3. *Barricadoes*, that is, a *Fence* made of *Paliſadoes*.

4. *Candileers*, that is, a *Frame* to lay *Fagots* or *Long Bruſhwood* in.

5. *Mantelets*, or *Blinds* made of *Boards* or *Long Planks*, and filled with *Earth* 4 or 5 Foot high, 1 Foot and an half thick, 1, 2, or 3 Rod long, which are moveable for to ſhelter the *Muſqueteers* and the *Workmen*.

6. *Gabions*, or *Cannon-Baskets*, which ought to be 3 or 4 Foot *diameter*, and 5 or 6 Foot high, filled with *Earth* well rammed down.

7. *Crow-Feet*, *Chaus-Traps*, or *Calthrops*, which are four pointed *Irons*, one Point always upwards.

8. *Musket-Baskets*, or *ſmaller Gabions* about a Foot and an half high, 8 or 10 Inches at the bottom, and a Foot at the top *diameter*, and are uſually placed upon *Low Breaſtworks*, or when the *Great Work* is beaten down.

9. *Canvas Bags of Earth* about a Foot in *diameter*, and a Foot and half in *length*, to be laid upon the *Parapets*, or on the edges of *Retrenchments*.

10. *Beetles* of all ſorts, to drive *Piles* or *Paliſadoes* with into the Ground.

11. *Gins* and *Drugs* for lifting up and ſhifting *Guns*.

12. *Shovels*, *Spades*, *Pickaxes*, *Wheel-Barrows*, *Hand-Barrows*, *Rammers*.

13. *Mortar-pieces*, great and leſſer, with *Granadoe-ſhells*, and all Materials belonging to them. *Hand-Granadoes* fitted with *Fuzes*.

Of the Line of Communication.

When the *Trenches* are brought to the Foot of the *Counterſcarp Bank*, then there ought to be made a *Line of Communication* betwixt the two or more *Approaches* that were carried on at one time. This *Trench* is to be filled with *Muſqueteers*, who are continually day and night to hinder the Enemy from ſhewing their Heads above the *Rampire*, while the *Cannons* are beating down the *Parapets*, and levelling the *Works*.

Of the Line called the Sapp.

This is a deep *Trench* or long *Chanel* directed to that part of the *Fortification* which is deſigned for the *Mine*, which is commonly one of the Faces of the *Bulwark*.

When you can no longer draw your *Trenches* obliquely, there is cut a ſtrait deep *Trench*, or long *Chanel* called the *Sapp*, through the *Out-Breaſt-work* directly to that part of the *Fortification* which is deſigned for the *Mine* and *Attack*, which is com-

commonly at the end of the Faces of the *Bulwark*.

This *Chanel* or *Trench* is made deeper than the reſt of the *Approaches*, and is covered above with *Boughs*, *Hydes*, or other neceſſary matter, to keep the *Pioneers* from the ſight of the *Beſiegers*.

Of the filling up of the Ditch, *and carrying over the* Gallery.

The *Sapp* being advanced through the *Out-Breaſt-work* and *Covert-way* unto the *Moat*, then great ſtore of *Pioneers* muſt be employed to carry *Earth*, *Fagots*, *Stones*, &c. in *Wheelbarrows*, or otherwiſe night and day to fill up the *Moat*.

The *Mount* is to be raiſed on that ſide which reſpects the Enemies *Courtain* and *oppoſite Flank*, and ſo to be wrought and carried on with ſuch a breadth, that the *Gallery* may be conveniently ſet upon it, the upper part of which muſt be well fortified againſt *Fire*, by being covered with a Foot and an half of *Earth*. Theſe *Galleries* are made of *Frames of Timber* ſome 8 or 10 Feet wide, and the height 9 Foot. And that ſide reſpecting the *Enemies Flank* muſt be double planked, or *Chandeleers* and *Fagots* may be planted to ſave the *Pioneers*.

Theſe *Frames* are to ſtand 6 or 7 Foot one from another, till the *Galleries* reach to the Foot of the *Bulwark*. In the univerſal affair of a *Siege*, there is not any *Enterprize* more dangerous than this.

Of

Of the Mine.

The *Gallery* being brought over to the Face of the *Enemies Bulwark*, the next is to make a *Mine*, which is done by *Miners* with Inſtruments fit for that purpoſe, and is generally made four Foot, or three and an half high and wide, but narrower the nearer you come to the place appointed. The *Chanel* is made winding by ſeveral turns wrought on to prevent the ſtrength of the *Powder* from coming out *forwards*, when the *Miner* is come to the place deſigned, which ought to be further than the outward *Talu*. Then he makes the place for the *Powder*, which is about 8 or 10 Foot wide, and 4 or 5 Foot high. Here he puts the *Barrels of Powder*, which muſt not be long there before the time of execution, leſt it grow moiſt and be ſpoiled. The Mouth of the *Mine* muſt be cloſe ſtopped, putting *croſs Timbers* in each Return, leaving a *Trunk* or *hollow Pipe* full of *Powder* for the *Train*, ſo that putting a *Match* to it, the *Mine* may be blowed up at the time appointed.

Of a Storm, *or* General Aſſault. *Plate* xxxiii.

Proceeding to a *General Aſſault*, the *General* gives Order for the *Breaches* to be viewed by ſome Perſon of great *Knowledge* and *Experience*, ſuch are the *Majors* and *Engineers*; and the Perſon ſent is generally armed *Cap-a-pe*, Muſquet-proof, and attended by a *Guard of Muſqueteers*. He obſerves the nature of the *Breach*, whether *wide enough*, whether *eaſie or difficult of Aſcent*, and how *annoy'd* and

and defended by the Enemies either *Flanking*, or oppos'd againſt thoſe that ſhall enter, and what *Annoyances* or *Defences* of the Enemy may be removed by new *Batteries*.

And now the *Storm* being reſolv'd upon, when every thing is in a *readineſs*, the beſt time to mount the *Breach* is in the day-time, when every one deſires, out of a *Noble Emulation*, to do his utmoſt; and *Cowards* are oblig'd to make a *Figure*, as having no way to hide themſelves, which they might do in the Night: Beſides, that the *Beſiegers Artillery* plays more exactly upon the *Defences* of the place, and upon the *Head* of the *Breaches*, than they could do in the Night: Beſides, that they who are commanded to enter the *Breach*, would be in danger in the dark of being kill'd by their *own Shot*.

Now as the *firſt Onſet* is an Honour coveted by Men of *daring Spirits*; there are many who claim it as their *Right* to be the *firſt*, though indeed the *Advantage* belongs to thoſe who that day had the *Guard* of the *Trenches*.

However, the *Signal* being given by a *Bomb*, or ſome other *luminous Ball* ſhot up in the *Air*, every one muſt go to the *Aſſault* according to his *Quality*, and the *Orders* he has received. Now in regard it is of high *Concernment* to give the *Beſieged* ſeveral *Diverſions* at the ſame time, and to *diſturb* 'em in their *Defences*, beſides the *two Breaches*, which are the leaſt *Number* that can be made in order to a *general Aſſault*, the General therefore hotly *alarms*, and *threatens* ſeveral other places with the *Scalado* at the ſame Inſtant.

The *first* that go to the *Aſſault* muſt be about 40, commanded by a *Lieutenant*, or an *Enſign*, and *two Serjeants*. They muſt be arm'd *Musket*, or at leaſt *Piſtol-proof*; the one half carry *Blunderbuſſes*, *Piſtols*, *Halberds*, and other *ſhort Weapons*; the t'other *Half-Pikes*, *Mantlets*, and *Bavins*, to make good their *Ground*.

Thoſe that follow the *firſt* muſt be *more* in Number, who muſt themſelves *be backt* with a more numerous *Supply*, every one making it their buſineſs to *relieve* and *reinforce* one another, till they have *lodg'd* themſelves upon the *Head* of the *Breach*.

Concerning *Mines*, I may add thus much more, without prejudice to the *Art*, That the *chiefeſt things* to be reſpected are theſe:

1. The *true diſtance* to a deſigned place.
2. The *direction of a Mine*, that you may not err in your courſe.
3. The *ſtrengthning of the Mine* with Timberwork; the *well ſtopping* of it; and the *well laying* of the Train.

Laſtly, The *Countermining* and *Croſsmeeting*; all which *Parts* have very many *Circumſtances* very conſiderable, and require a *larger Diſcourſe* than can be afforded in this place; only thus much, that *Mines* are much better than *Batteries*, where you can *come* to make uſe of them with any *Expedition*; becauſe of their *ſudden* and *unexpected Operations*.

Thus have I briefly given plain and eaſie *Rules* for all *Modern Fortifications*.

Of

Of Gunnery.

FOraſmuch as the *Secrets* of the *Art of Gunnery* are numerous, and that thoſe *Myſteries* are publiſhed and ſet forth by others of *great and able Skill and Science therein*, eſpecially by my *ingenious Friend* Mr. *Robert Anderſon*, in his late *genuine Uſe* and *Effects* of the *Gun*, as well *Experimentally* as *Mathematically* demonſtrated, with *Tables of Projection*, &c. exactly *Calculated*, and their *Uſes Exemplified*:

Wherein he hath *laid down* 50 *Propoſitions* concerning *Practical Gunnery*, by which you may,

1. From any *Shot of a Piece*, however made, find the *greateſt Random*.

2. The *Complication* and *Relation* of all *Guns* of the ſame *kind* amongſt themſelves; and hence the *Dimenſions* and the *Requiſites* of *Powder* of any *Piece*, a *Rang* anſwering to any *Degree* being given; to find the *Requiſite* of *Powder* of any other *Piece*, and to *ſtrike* any place, *at demand*, within its *reach*, its *Dimenſions* alſo being given.

3. The *Nature*, *Property* and *Uſe* of *Mortar-Pieces*, with their *Complications* and *Relations*.

4. Alſo the *ſhooting of Granadoes* out of *long Guns*, with their *manifold Uſes*, &c.

By which *new Art* and *Method* of *Shooting*, he tells us a *Cannoneer* may do *ſtrange Execution* on an *Enemy* at a far *greater diſtance* than is ſet down by other *Authors*.

By

By this, from a *Caſtle* or *Fort*, taking the *Diſtances* at leiſure of all ſuch places by which an *Enemy* may approach, the *Enemy* may receive ſo much *detriment*, that it will be impoſſible for him to be Maſter of that *Fort* or *Caſtle* by *Storm*.

By this, may an *Army* be extremely *annoyed*, although at 4, 6, or 8 *Miles* diſtance.

By this, a *Fire-Maſter* may lay his *Granado* or *Fire-Ball* at any place, *at demand*, and give its *Fuſee* its juſt time.

By this, the *General* of an *Army* may ſpeedily *win the Field*; perform *unexpected Batteries* at *great Diſtances*; and *deſtroy* many of his *Enemies*, before they *think themſelves* within the *reach* and *danger* of his *Artillery*.

The *like Service* may be done *upon Ships at Sea*, at *great Diſtances*, though there the *Direction* of a *Piece* is always *leſs certain* than at *Land*.

By this a *Gun-Founder* may caſt *Guns*, *according to demand*, either for *Rang*, *Force*, or *Time*, with many other *ſtrange Things* in this *Art*.

I ſhall therefore omit to write any thing more, relating to that *Art*, but commend him, that would be an *ingenious Artiſt*, to the peruſal of that Book, a Work of *ſingular Uſe* unto *Generals* of *Armies*, *Engineers*, and other *Artiſts*. Sold by *Robert Morden* at the *Atlas* in *Cornhil* near the *Royal Exchange*, London.

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FINIS.